Idaho State University

Prototype Consequence Modeling Tool Based Upon the Hybrid Single Particle Lagrangian Integrated Trajectory (HYSPLIT) Software

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Acronyms

ATR	Advanced Test Reactor
CEDE	Committed Effective Dose Equivalent
GPS	Global Positioning System
GUI	Graphical User Interface
HERON	HYSPLIT Enhanced RAVEN Oriented Nuclide-dispersion
HYSPLIT	Hybrid Single Particle Lagrangian Integrated Trajectory
INL	Idaho National Laboratory
ISU	Idaho State University
LWRS	Light Water Reactor Sustainability
MACCS	MELCOR Accident Consequence Code Systems
MOOSE	Multiphysics Object-Oriented Simulation Environment
NOAA	National Oceanic and Atmospheric Administration
NPP	Nuclear Power Plant
NRC	Nuclear Regulatory Commission
PRA	Probabilistic Risk Assessment
RAVEN	Reactor Analysis and Virtual Control Environment
RISMC	Risk-informed Safety Margin Characterization
SAPHIRE	Systems Analysis Programs for Hands-on Integrated Reliability Evaluations
SNL	Sandia National Labs
TEDE	Total Effective Dose Equivalent
U.S. DOE	United States Department of Energy

Executive Summary

While Level-1 and Level-2 PRA address core damage frequency and the quantity of radioactive material released to the environment, Level-3 PRA deals with the consequences of a release. The consequences can take the form of health effects as well as economic impacts. The radioactive plume atmospheric dispersion model used in the consequence analysis plays an influential role in assessing the impacts. Lagrangian dispersion models are based on the understanding that the plume particles move in the atmosphere along trajectories determined by atmospheric conditions such as wind, buoyancy and turbulence. HYSPLIT is a sophisticated Lagrangian dispersion model computing package produced by the National Oceanic and Atmospheric Administration.

RAVEN is a software tool developed at INL that primarily functions as the control arm for dynamic PRA analysis. HYSPLIT was linked with RAVEN to perform comprehensive Level-3 PRA analysis. HERON (HYSPLIT Enhanced RAVEN Oriented Nuclide-dispersion) was developed to allow RAVEN to run HYSPLIT recursively while perturbing the HYSPLIT input through Monte Carlo sampling. The RAVEN data analysis tools then allow interpretation of the probabilistic result of the repeated HYSPLIT executions.

The development of HERON was in conjunction with the Risk-informed Safety Margin Characterization Program under the U. S. Department of Energy (DOE) Light Water Reactor Sustainability Program which seeks a systematic approach to quantify the impact on safety and economics in relation to various nuclear power plant operational management decisions.

1. Introduction

Risk-informed Safety Margin Characterization (RISMC), as a part of the U. S. Department of Energy (DOE) Light Water Reactor Sustainability (LWRS) Program, is a systematic approach used to quantify the impact on safety and economics in relation to various nuclear power plant (NPP) operational management decisions. One of RISMC's main goals is development of sophisticated software tools that support more accurate representations of nuclear power plant safety margins. Calculation of the probabilistic safety margin, which is the probability that a key safety metric will be exceeded under specified accident conditions, is enhanced when computational models represent more realistic NPP system behavior. Safety margin probabilities calculated for various scenarios leading to hazardous conditions can be compared and used for better informed decision making purposes.[1]

In 1995, the U. S. Nuclear Regulatory Commission (NRC) announced a policy statement encouraging the use of Probabilistic Risk Assessment (PRA) and associated sensitivity studies in NPP design, licensing, and continued operation to minimize overly conservative methodology.[2] Over time computational tools have been developed towards this end. Systems Analysis Programs for Hands-on Integrated Reliability Evaluations (SAPHIRE), developed at Idaho National Laboratory (INL), is a robust static Level-1 PRA computational tool based on events and fault tree scenarios.[3] With SAPHIRE, an initiating event begins progress along a fault tree containing two or more nodes wherein possible related events are evaluated for probability of success or failure. Event probabilities are mathematically combined and propagated, node by node, until the final node of interest, usually the node representing core damage, and corresponding probability is ascertained. These models will give an indication of the most problematic scenarios to address in NPP management decision making, yet they do not take into account system time dependencies of component failure and possible recovery. Since the associated probability estimates do not reflect all possible state transitions of the NPP system, the probability estimate is inherently conservative.

The dynamic PRA model introduces a method for NPP system time dependent failure/recovery analysis that is built upon the static PRA model based on events and fault tree analysis. In dynamic PRA, the question is not just whether or not a component fails but when, and is it recoverable. Such a software enhancement has already been demonstrated successfully in a case study conducted on the Advanced Test Reactor (ATR) at INL.[2] In the ATR case study, the PRA upgrade included the use of a dynamic PRA simulation model integrated with a sophisticated thermal hydraulic performance code, RELAP5. Given changes in systems or component status from a PRA scenario simulation, the RELAP5 code was used to evaluate system response. This application of PRA modeling enhancement led to the ability to evaluate several accident scenarios; whereas RELAP5 alone was limited to a select few.

The next generation thermal hydraulic computational tool, RELAP-7, is under development as a Multiphysics Object-Oriented Simulation Environment (MOOSE)-based application. MOOSE is a multiphysics framework that allows for continuous integration of software developer changes from contributors in various scientific disciplines to allow for the rapid development of a highly sophisticated scientific modeling tool.[4] The Reactor Analysis and Virtual control Environment (RAVEN) tool has also been under development at INL to couple dynamic PRA with RELAP-7.[5] The development is geared primarily toward Level-1 PRA, which addresses NPP event scenarios that could ultimately lead to core damage. Core damage means release of radionuclides into the surroundings. The extent to which back up containment is effective in protecting the outside NPP environment from contamination is a matter for Level-2 PRA. Level-3 PRA analysis begins at the point of accidental release from an NPP into the environment with potential for exposure to the public. The questions answered by Level-3 PRA include: the probability of contamination of the environment at surrounding locations, and the consequences, both radiologically and economically. The results of such analysis will inform the decision making process regarding appropriate safety measures needed to mitigate the consequences of accidental release and ensuing economic impact.

Level-3 PRA analysis is currently supported by MELCOR Accident Consequence Code Systems (MACCS2), developed at Sandia National Laboratory (SNL), in which the linear Gaussian plume model is used to represent atmospheric dispersion of radionuclides. Studies conducted with simple tracers revealed that computational codes using the linear Gaussian plume dispersion model tend to over predict radionuclide concentrations, and under predict radionuclide spread.[6] The Hybrid Single Particle Lagrangian Integrated Trajectory (HYSPLIT) model developed by the National Oceanic and Atmospheric Administration (NOAA) is a more realistic atmospheric contaminant dispersion model as it utilizes measured meteorological data gathered from selected weather towers within the region of concern to seed atmospheric dispersion calculations. For example, data from surrounding weather towers is integrated to produce a 3D wind vector grid. The wind vectors are seldom unidirectional or uniform in speed and are rarely constant in time. These vectors form the bases of radionuclide transport in the HYSPLIT model. HYSPLIT is based on 3D, time-dependent mathematical operations, and has been successfully developed and used in conjunction with weather towers at INL.[7] Extension of this capability is desired for NPPs within the United States.

It is proposed that the RAVEN dynamic PRA tool under development at INL, interfaced with the MOOSE-based thermal hydraulic application RELAP-7 also be developed to interface with HYSPLIT for Level-3 PRA analysis. This proposal supports an effort by RISMC lead, Dr. Curtis Lee Smith, to continue to move toward the goal of "creating an advanced RISMC toolkit for a more accurate representation of NPP safety margin."[2] Idaho State University (ISU) was awarded a contract, see Appendix A for the Statement of Work, to develop the initial integration of HYSPLIT into RAVEN. Under the direction of Dr. Chad Pope, a team of graduate students from the ISU department of Nuclear Engineering and Health Physics has been tasked to build a RAVEN control module and a RAVEN/HYSPLIT interface to enhance Level-3 PRA.

The set-up of the working environment included acquisition of HYSPLIT source code files and related documentation, obtaining a software license for RAVEN and consequently MOOSE, and the installation of the various files onto computers housed at ISU sufficient for high level programming and initial testing. Initial work began in May of 2014 and completed in September 2014. The HYSPLIT source code and associated documentation was obtained from NOAA June 21, 2014; however, installation of the files required special software packages and could not be fully installed until mid-July. The RAVEN software license, see Appendix B, was obtained July 1, 2014, which is effective for three years. Given the complexity of the various codes, the different output and input formats of the programs, a simple proof-of-principle scenario utilizing the sampling capability of RAVEN to sample a single isotope source term and a fixed HYSPLIT weather scenario, along with the post processing of one key safety metric, inhaled dose, was prepared. The initial proof-of-principle test demonstrates that RAVEN can indeed be coupled with HYSPLIT.

2. Level-3 Probabilistic Risk Assessment

PRA is used, *inter alia*, to estimate risk in terms of quantifiable values. By using numerical inputs to symbolize the chances of something going wrong and the consequences of such events, PRA can give a more accurate portrayal of the risks involved in engineering than more qualitative approaches such as worst-case scenario assessments, selected by fiat, which tend to overestimate the risk involved.

Risk assessment is a method of determining the likelihood of a specific set of undesired consequences. Risk involves both the likelihood of an undesired event, often expressed as a frequency such as one event per thousand years, and the severity or magnitude of the consequences of the event. PRA is an analytical tool which is used to identify potential accident scenarios, estimate the likelihood of each scenario, and estimate the consequences of each accident scenario. The safety of an NPP can be quantified as the efficacy of the NPP divided by the risk of running the NPP. The efficacy of an NPP is defined as the likelihood of a specific set of positive results from operation multiplied by the benefit of those positive outcomes. Whereas risk is the frequency of a negative result multiplied by the negative consequences that would result. For an NPP to be considered safe, the efficacy must be much greater than the risk.

PRA is divided into three levels of risk. These levels each focus on different probabilistic models of accident scenarios. Each level builds on the previous level, using its assessment of probable risk as the input for its assessment. These levels combine to provide a comprehensive picture of accident scenarios, responses, and consequences which can be used by engineers and regulators to reduce the risk inherent in any NPP.

The first level of risk assessment is local to the NPP. A Level-1 PRA models the risk of an accident occurring at the NPP. An accident or other event which negatively impacts NPP operation is known as an *initiating event* and part of the Level-1 assessment is measuring and estimating the probabilities of such events. Included in this assessment are also NPP responses to initiating events. These responses are known as *accident sequences*. An initiating event may give rise to many different accident sequences depending on the behavior of the response systems. A given accident sequence starts with the initiating event and then assesses the response of each system designed to protect the NPP. An accident sequence will take into account whether systems operate properly or fail as well as the actions taken by operators. Each of these accident sequences shows a possible sequence of events which could happen in response to an accident. Some of these pathways lead to core damage and some lead to a safe recovery. The accident pathways may be visualized by the use of *event trees*, as shown in Figure 1.[8] Each box in an event tree is known as a *top event* and denotes a system that is supposed to respond to the initiating event. In the example figure, the main chute of the parachute is supposed to deploy with some probability upon the occurrence of the initiating event (pilot falling from the plane). Because no safety system can guarantee 100% reliability, there are backup systems. If the main chute fails to open, the backup chute will attempt to open with some probability. This is the second box on the event tree. In the case of the main chute opening as planned, the jumper floats safely to the ground. If the main chute fails, the reserve chute may either work as intended or fail. An event tree for an NPP would have many more systems and a wider variety of initiating events.

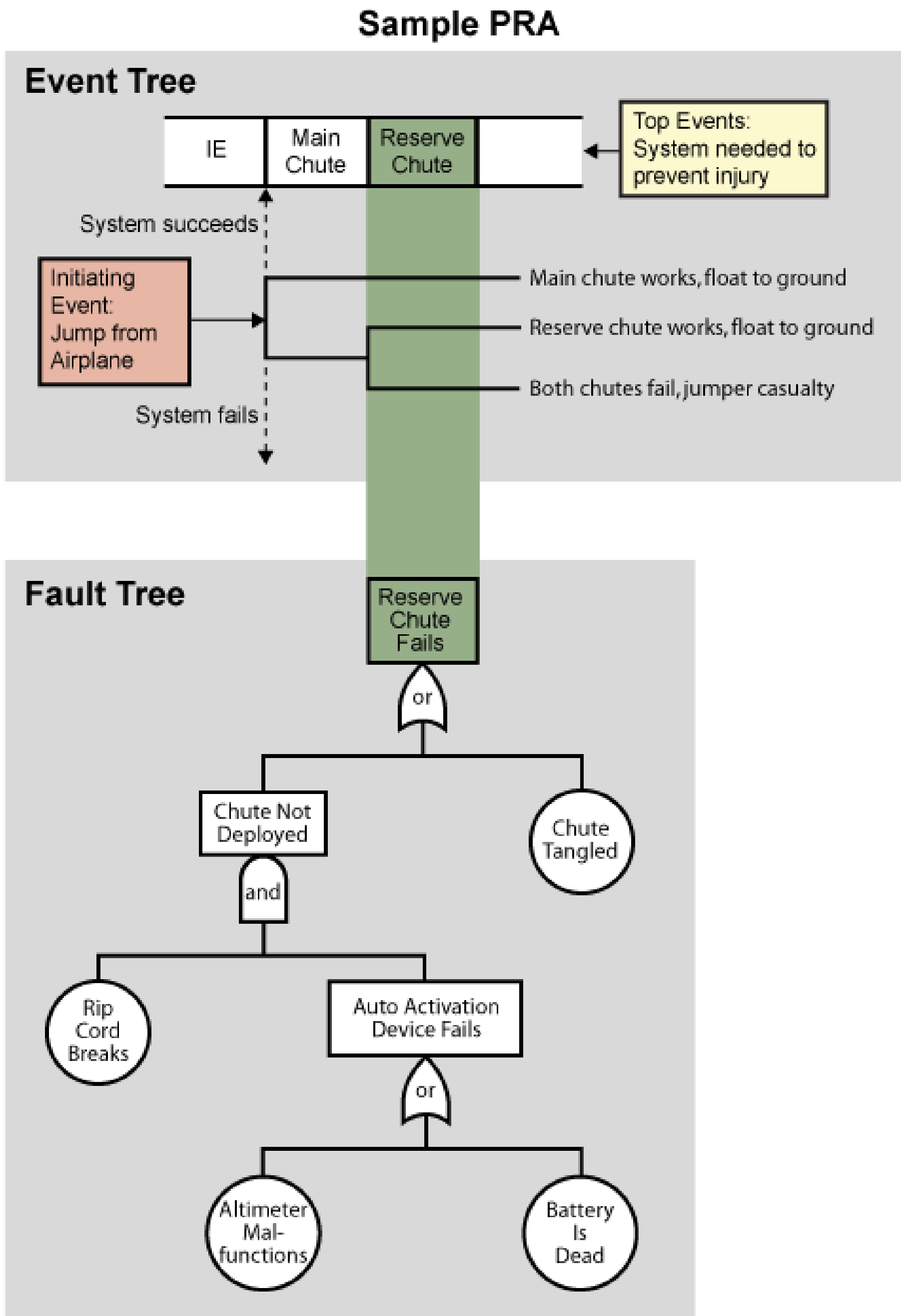

Figure 1. Event tree - Fault tree example.

An analysis of each event is visualized in a *fault tree* also shown in Figure 1. The fault tree shows the full accident pathway in the form of a logic tree, with *and* and *or* nodes showing the logic of the progression of each accident scenario. Each event on the tree has a corresponding probability associated with it. For example, the parachute has a certain probability of not deploying and the backup chute has a certain probability of deploying if the main chute fails. By adding or multiplying these probabilities together for each accident scenario, a quantifiable measure of the risk of jumping out of a plane can be calculated. In nuclear regulatory framework, the chance of each different initiating event is calculated and each accident pathway is examined giving a probability of core damage expressed as a frequency (*e.g.*, 1 in 10^5 years). This provides the first level of risk assessment: the expected frequency of core damage. This core damage frequency is then the input to the second level of PRA which deals with characterizing the chances and types of releases for a given chance of core damage.

After examining all possible ways core damage could occur, including the responses of safety systems and operators, probability distributions representing the frequency and type of core damage are produced by the Level-1 analysis. The second level of PRA builds on the Level-1 assessment by modeling the plant's response to those accident scenarios which the Level-1 analysis resulted in core damage. Level-2 analysis estimates probabilities that a plant can contain a given Level-1 accident scenario. The progression of the accident is analyzed based on the input from the Level-1 model and follows the efforts of the plant systems to contain the accident. Level-2 PRA considers the initial state of the structure and system as well as its behavior under the stress of a core damage situation which may involve hazardous materials. Level-2 PRA considers whether the core damage causes other systems to fail, *e.g.*, steam generator tubes rupturing, and how such failures would affect other systems in the plant. It also assesses consequences of various reactor core configurations as they pertain to the potential failure of other systems and containment of the accident. Once the plant response to an accident has been characterized, the Level-2 analysis can output a probabilistic model of the potential for the plant to release radioactive material into the environment. This model is then the input for the third level of PRA which deals with the consequences of releasing radionuclide contaminants into the environment.

Level-3 PRA is sometimes known by the alternate name of 'consequence analysis'. Whereas the Level-2 analysis deals with modeling the release of radioactive material, Level-3 deals with the consequences of the release to the general public. Consequences can take the form of health effects to a population which include both short term injuries from releases and longer term ailments such as cancers. To model health effects quantitatively, probabilistic models of radiation exposure are used. These models take into account the chance of a certain dose being received by a member of the public and the chances that injury will result from a given dose. Level-3 PRA also deals with economic consequences of a release. Economic consequences can include the cost of clean-up, the value lost to land contamination, and any other effect of the release with a monetary impact on the public.

The Level-2 result contains the characteristics of the release which the Level-3 assessment will model. These characteristics include the type of radiation released, the isotopes in the release, and their dispersion related properties. The Level-3 model then simulates how a given accidental release will disperse throughout the surrounding area. This dispersion depends on simulated weather data and has a stochastic element giving a probable path for the released isotopes to travel. This path is dependent on wind and weather conditions around the NPP. The release plume will follow wind direction making accurate modeling of these conditions crucial to the accuracy of a Level-3 analysis. The plume spread also depends on the weather. In rainy conditions, isotopes precipitate out of the atmosphere limiting how far they can disperse. Because the weather is uncertain, a probabilistic model of the plume dispersion gives a distribution of doses for a variety of situations per location. The consequences then depend on the population in the area surrounding the plant and the ease of evacuation for those people likely to be effected. The effect on the land depends on the make-up of the surrounding area and how that land is utilized. The output of the Level-3 PRA is then a probabilistic model of the consequences for a given accidental release scenario. Combining the outcomes with their probabilities is what allows an assessment of the risk of the plant.

As depicted in Figure 2, the three levels combine to show the assessor a comprehensive picture of the risk associated with the NPP operation.[8] The first level outputs the frequencies of core damage, the second level models the frequencies of release to the environment in the event of core damage, and the third level gives the probabilities of the consequences in the event of a release. For example, a given NPP might have a 1 in 10^5 chance of core damage, and another 10^{-2} chance of release given core damage which would then result in 10^{-4} chance of cancer in the population. Multiplying these frequencies together would give an assessment of the risk of running the NPP.

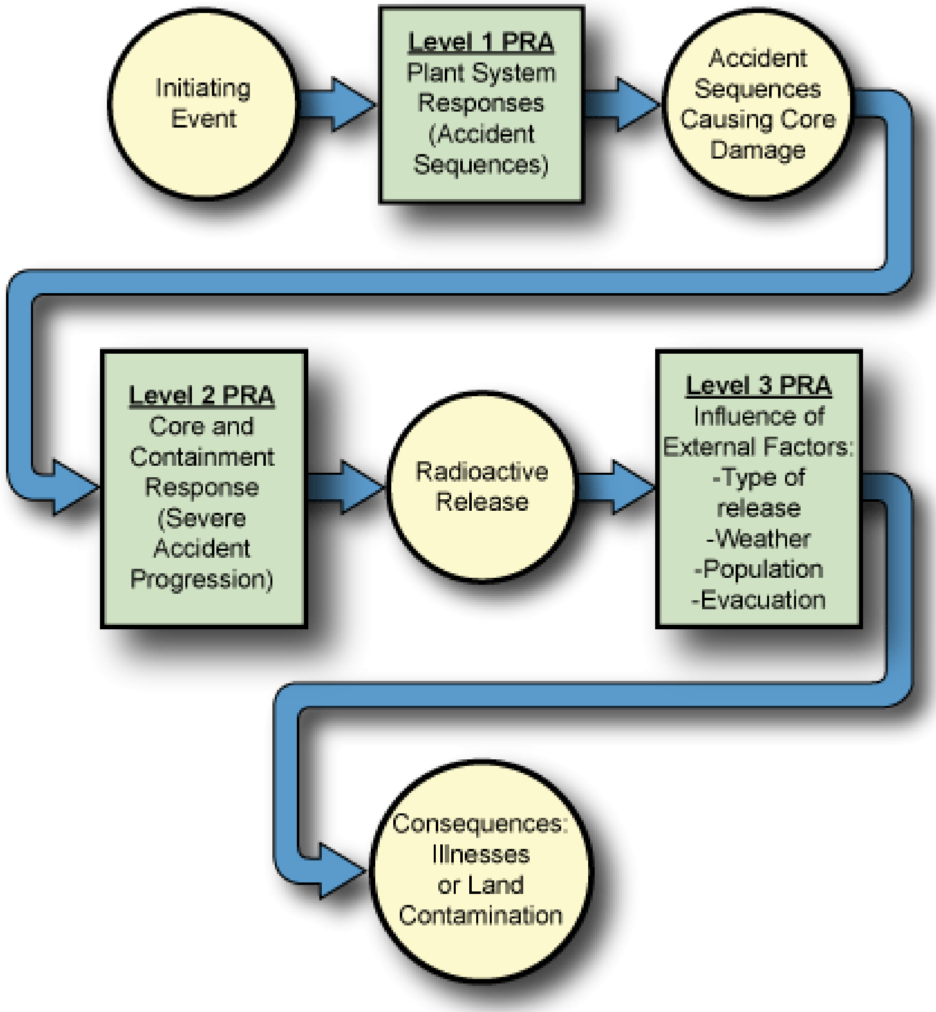

Figure 2. Three Levels of PRA

3. Radioactive Material Atmospheric Dispersion

In the case of a radiological accident, concentration predictions of radioactive materials in the environment are of great importance to implement effective protection countermeasures for public health. These predictions can be significantly enhanced by introducing Lagrangian mechanics into the atmospheric dispersion computational model. Lagrangian methods take into consideration snap-shots in time, and make use of a three-dimensional velocity vector. Rather than modeling the release as a plume traveling in one direction with a Gaussian spread, the release is modeled per particle or puff transported over snap-shots in time in the direction of the wind field vector at the location of incremental transport.[7]

There are many potential pathways by which radionuclides released into the atmosphere may give rise to doses to individuals. The most likely dose-contributing pathways from an atmospheric release standpoint would include the inhalation and external pathways. However, the importance of each pathway depends in part upon the nuclide involved. For normal releases of airborne activity from nuclear facilities the radionuclides of importance include, but are not limited to, ^{60}Co, ^{131}I, and ^{137}Cs. The other less volatile airborne radionuclides usually have various forms and levels of filtration applied to minimize the levels released.

The use of models for atmospheric dispersion of a radioactive plume plays an influential role in assessing the environmental impacts caused by the nuclear accident. Atmospheric dispersion modeling is essentially the attempt at describing the relationship between the radioactive emission and the resulting concentration at some point over time. Many instruments are available for measuring radionuclide concentrations, but these results are basically a measurement of a location at a particular point in time. Atmospheric dispersion modeling, on the other hand, is based on a series of mathematical equations which serves as a tool for predicting consequences in terms of concentrations and radiological doses for various hypothetical release scenarios. With the use of atmospheric dispersion modeling, the ability to foretell any possible emergency situation is expanded and preventative measures may be applied to avoid possible catastrophes.

There are two main model types commonly used for atmospheric dispersion modeling: the straight-line Gaussian plume model and Lagrangian trajectory model. Although the oldest of the models used, the Gaussian model is perhaps the most commonly used model type. The Gaussian model, depicted in Figure 3, assumes the radioactive plume dispersion has a Gaussian distribution. These models are most often used for predicting the dispersion of continuous, buoyant plumes originating from ground-level or elevated sources. The Gaussian plume model is adequate for estimating concentrations up to 10 km downwind from a continuous source in relatively flat terrain. There is no possibility for taking into account curvature in the wind direction.

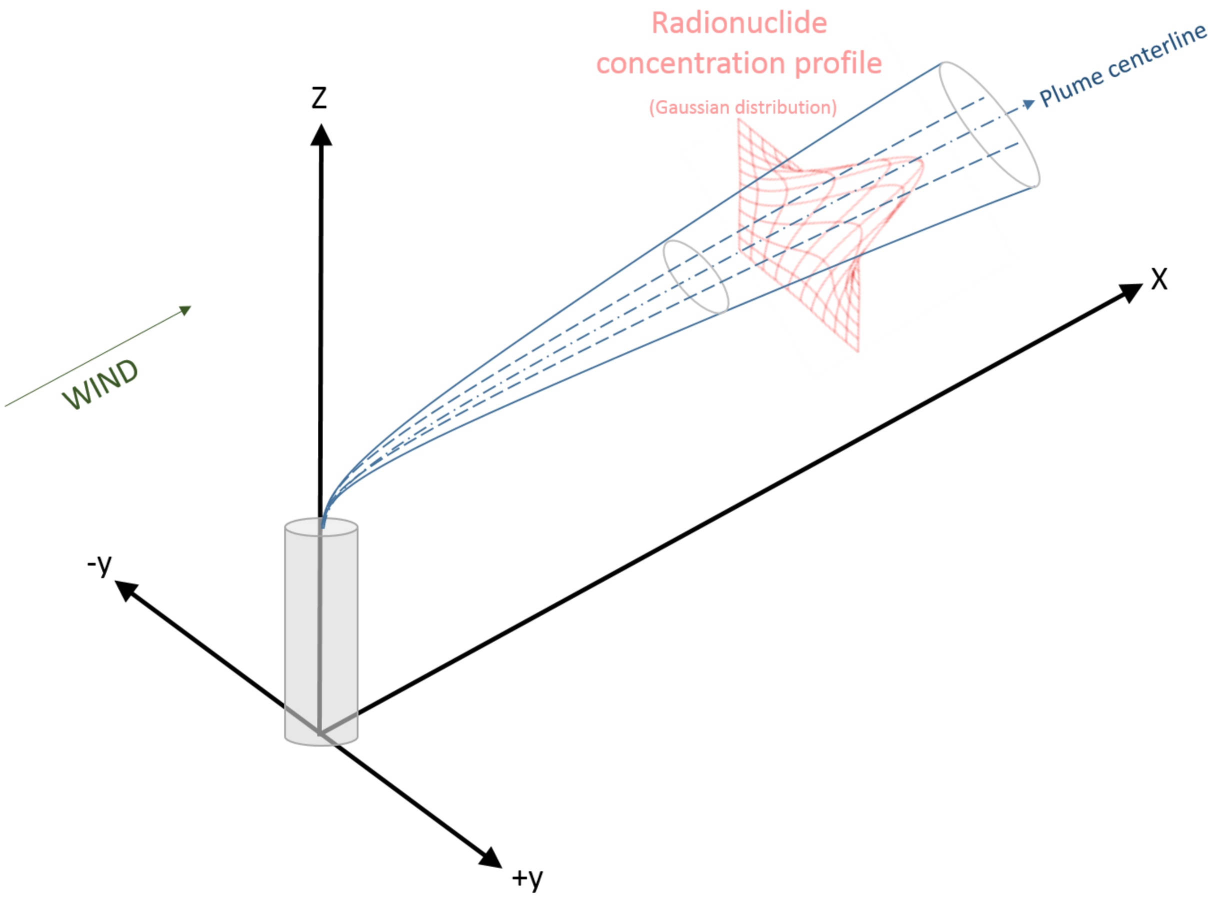

Figure 3. Gaussian plume model.

Many assumptions are made with the straight-line Gaussian plume model. The Gaussian plume model assumes that the emission rate is constant. The dispersion, or diffusion of the radioactive plume, is negligible in the downwind direction is another assumption. The model also assumes the horizontal meteorological conditions are homogeneous over the space being modeled. For each hour modeled, an average wind speed is used, wind direction is constant, temperature is constant, atmospheric stability class is constant, and the mixing height is constant. The model also assumes there is no wind shear in the horizontal or vertical direction. The model assumes the plume is infinite with no plume history (each hour modeled is independent of the previous hour). The pollutants are assumed to be non-reactive gases or aerosols that remain suspended in the air following the turbulent movement of the atmosphere. The plume is assumed to be reflected at the surface with no deposition or reaction with the surface. Most importantly, the model assumes the dispersion in the horizontal and vertical planes take the form of Gaussian distributions about the plume centerline.

The main disadvantage of the straight-line Gaussian model is that it cannot deal with changing wind speeds or directions, which result in a drastic change in the concentration downwind. The Gaussian model is also limited to a useful distance to that which the plume travels under fairly constant meteorological conditions (about 10 km). The accuracy of the Gaussian model is reduced by building and sharp terrain features. The Gaussian limitations drive the need for use of Lagrangian models.

Lagrangian models are based on the understanding that the plume particles move in the atmosphere along trajectories determined by atmospheric conditions such as wind, buoyancy and turbulence. Such trajectories are simulated and the final distribution of many particles results in a stochastic estimation of the concentration field. These simulations will either estimate the particle as an individual drifting point, from which the final distribution of numerous particles is used in estimating concentration fields, or a Gaussian distribution is assumed inside each particle and the final concentration is determined as a superposition of these Gaussian distributions, also known as puff models.

In the Lagrangian puff model, the source is simulated by releasing pollutant puffs, each of which contain the appropriate fraction of pollutant mass and are released at regular intervals over the duration of the release. The puff of pollutant is transported according to the trajectory of its center position while the size of the puff expands in both the vertical and horizontal directions in time which accounts for the dispersive nature of a turbulent atmosphere.

In the particle model, on the other hand, the release of many particles from the source is simulated over the duration of the release. Each particle has a random component to the motion added to each step in addition to the transportation motion which satisfies the atmospheric turbulence at that time. In this manner, a group of particles released at the same point will expand in space and time dispersing throughout the atmosphere. Theoretically, in a homogeneous environment the size of the puff at any particular time should correspond to the second moment of the particle's position.

In some models, the calculation uses particle dispersion in the vertical direction and puff dispersion in the horizontal.[9] This approach is used by HYSPLIT.[7] Regardless of which approach is used, stability and mixing coefficients need to be computed from the meteorological data.

Since the wind does not always blow in the same direction, nor is the terrain always flat, the Lagrangian models take these factors into account. In the puff model, depicted in Figure 4, releases are modeled as a series of puffs that grow in size as they are carried with the wind, resulting in dilution of the entrained contaminant. The concentration of material at a particular point in space is modeled as the average concentration of the puffs passing over the point of interest during a given time interval.

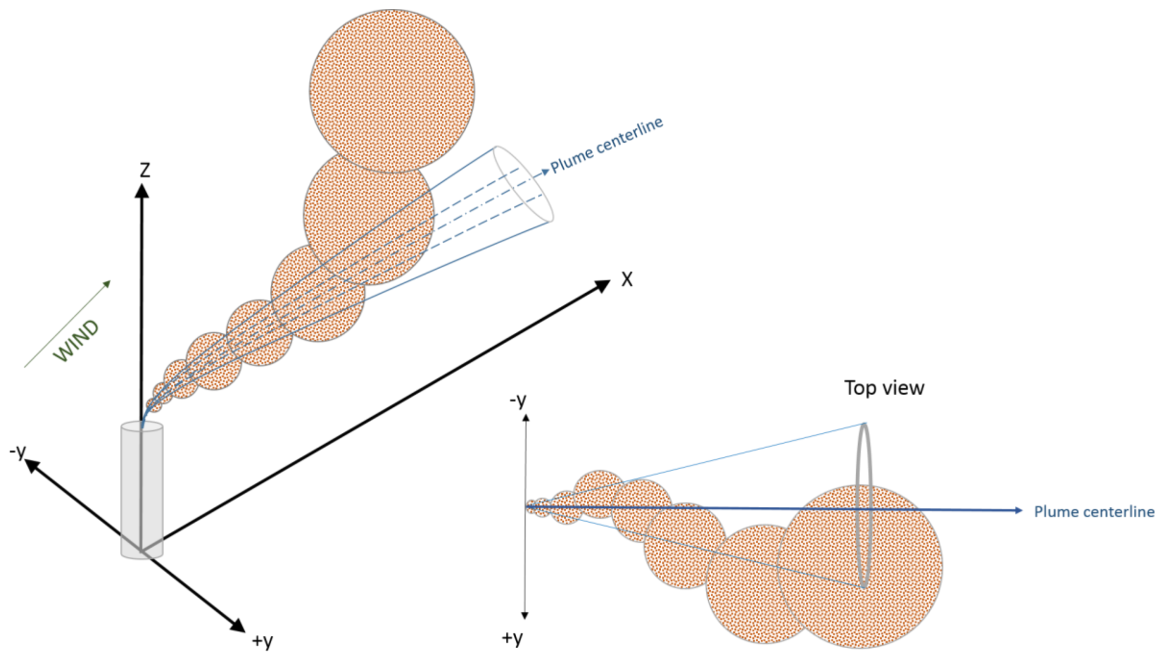

Figure 4. Puff model.

Since the wind direction and velocity in the vicinity of the puff determines the path of each puff, the need for more detailed meteorological data is required for this type of model, and is more than the straight-line Gaussian model can provide. In typical applications, data from ten or more meteorological towers are computed and modeled to produce gridded wind field maps giving for each grid sector the wind speed and direction at specific time intervals. The model moves each puff for the specified time with the speed and direction obtained from the nearest wind field grid vector. The growth rate of the puff is determined by the atmospheric stability.

4. RAVEN

RAVEN is a software tool currently under development at INL that primarily functions as the control arm for dynamic PRA analysis. Dynamic PRA is essentially a blended approach between probabilistic analysis and mechanistic analysis.[2] In this case, the blend consists of a SAPHIRE based PRA analysis tool coupled with a mechanistic analysis tool, RELAP-7, which is currently being developed as a finite element analysis MOOSE-based application to enhance the capabilities of its thermal-hydraulic code predecessor, RELAP-5, and become the main reactor systems simulation tool for RISMC.[5] Although RAVEN has been developed to interface with RELAP-7, the code is structured in a highly modular fashion, meaning a variety of stand-alone functions can be called in a variety of sequences to perform the task or tasks at hand making it simple to plug into other applications. A complete interface module can be accepted into the RAVEN framework without disturbing the complex functionalities of RAVEN. Programs written in different languages also can be simply modified to successfully link with RAVEN without rewriting the program in another language.

INL developers, under the direction of Dr. Christian Rabiti, have demonstrated the advanced capabilities of RAVEN in a simulation of a simplified PWR loop with a station black-out initiating event. Although the PWR loop is fairly simple, the PRA analysis is fairly complex. RAVEN could step through a fault tree scenario, Monte Carlo sample selected variables such as diesel generator recovery time or cladding fail temperature, initiate and monitor a system response calculation to the given input parameters (mathematically complex), and generate plots of the resulting output distribution after several runs. RAVEN can generate several types of 2D and 3D plots. RAVEN can also build common distributions, such as lognormal or Gaussian, for a given variable if certain distribution parameters are given. More sophisticated data mining algorithms capabilities are also in developmental progress.[5]

Recent RAVEN development has focused on Level-1 PRA; however, RAVEN can easily be expanded to process through Level-2 and Level-3 PRA as well, provided that specialized computational tools for coupling exist. Level-2 computational tools need to be developed. HYSPLIT is an excellent candidate for coupling with RAVEN to perform Level-3 PRA analysis. RAVEN developers have constructed an interface module that has been structured to more easily link RAVEN capabilities with any desired application. The interface module consists of an object class wherein RAVEN specific named methods for special categories of functions are coded with specialized performance commands unique to the coupled code. The categories include: the initialization of variables and the commands needed to run the coupled code, update of variable inputs for sequential runs, and the post processing actions to be implemented (such as plot generation). The interface is coded in Python and will accept *csv* input files. The control script for a RAVEN run is written in extensible markup language (*xml* files). This allows for a variety of sequences to be tried without rewriting the entire program. See Section 6 for the control script file and interface file written for this project.

5. HYSPLIT

HYSPLIT is a computing package produced by the NOAA Air Resources Laboratory (ARL). The purpose of which is to provide complex dispersion and deposition prediction of atmospheric pollutant releases utilizing both standard and non-standard weather data. This has practical applications in disaster type situations where HYSPLIT can track as well as predict a pollutant plume whether it is a volcanic release or chemical spill. This allows emergency responders to effectively deploy their forces and evacuate danger areas without the long wait time of in-person situation reports.

The source code of HYSPLIT is written in Fortran and can be compiled onto a wide variety of operating systems and computing environments such as Microsoft Windows, Apple OSX and Linux. The Windows and OSX executables are available to the public on the HYSPLIT website.[10] The Linux executable is available either by compiling the source code or requesting the executable from NOAA. HYSPLIT has also been deployed online and contains an easy to use graphical user interface (GUI). The GUI contains many features which were not used in our demonstration problem, all of which can also be utilized in the input files. HYSPLIT also has routines which calculate deposition of pollutants across a gridded area. Multiple levels can be set to cover both airborne concentration and deposition.

Historical atmospheric models utilize a Gaussian plume model which assumes a constant source, a plume spread with a normal distribution and a constant wind speed and direction. The main disadvantage of the Gaussian model is that the constant weather assumption does not match any real life disaster scenario. Most real world scenarios happen over a matter of hours where weather conditions can rapidly change. HYSPLIT uses more complex Lagrangian models either assuming a particle or puff model. Lagrangian models have the main advantage that they track particle motion across a non-uniform wind field with varying meteorological conditions. This type of modeling makes pollutant tracking more representative of real world phenomena and enables accurate tracking of atmospheric pollutant releases. It is because of this feature that HYSPLIT was selected as the code to advance Level-3 PRA.

HYSPLIT can process many different types of meteorological data for use in pollutant tracking. The reason for this is because meteorological data comes in many different formats and interpolations. Most meteorological data have built-in interpolation functions because weather stations do not exists on regular discrete intervals of the area in question. This means that specific data like temperature, wind speed, etc., are sampled at one or a few locations and are then processed to interpolate those same values across a given area. This is necessary because the areas in question are vast in comparison to the points of measurement. The interpolations can take the form of simple linear interpolations to full forecast models both of which end up with a field of grid points at multiple elevations. All of the schemes of interpolation define their own coordinate systems which might differ from how the users define their problem grid, causing difficulty when merging applications.

HYSPLIT has the ability to import a variety of forms of gridded meteorological data and either use their existing grid structure or transform the grid into user specified parameters. While the specifics of how this process works is beyond the scope of this project, there is room for future improvements of how the meteorological data can be processed to gain more information related to probable dose. The ultimate goal for future work would be to create a program which would sample different meteorological databases randomly for a specific area. This would enable an output of dose distributions based on most probable weather patterns. The major benefit to Level-3 PRA would be the ability to assess risk to the public based upon all factors of an accident. Areas that receive 50 inches of precipitation per year would have a very different risk assessment than areas which have little to no precipitation. It would also lead to the analysis of the end points of a weather distribution. Weather events which are low frequency and low consequence could be analyzed for potential chances in risk when coupled with a particular accident event. On the other end of the spectrum, weather events which have low frequency and high consequence could lead to large changes in risk. The potential for improvement will exist for future work, which can bring large benefits in terms of risk assessment and reduction.

There is one main limitation that exists within the HYSPLIT framework. True measurements of non-interpolated meteorological data exist only where there are weather stations to take measurements. On the macroscopic scale, this is not a problem. Weather stations exist in abundant quantities when considering areas the size of the United States. The uncertainty can be low for large nationwide forecasting because of this abundance of data points, but for some areas this value can be as low as one. An example of this is low population density areas. In order to use these points, forecast models have to be used in order to generate gridded metrological weather data that can be used in programs like HYSPLIT. HYSPLIT is a very advanced software but it can only produce results as good as the uncertainty in the input data.

HYSPLIT requires a minimum of three files to run properly; 1) *control*, 2) *setup.cfg*, and 3) *weather data*. The weather data file can be in multiple different formats and has the option of being split up into multiple files. The control file defines the parameters of the pollutant release an example of which is shown in Figure 5.

```
14 07 29 16 50
1
43.5844 -112.9686 0
3
0
5000.0
2
./
ARWDATA.BIN
./
ARWDATA.BIN20
1
CS37
52.1966757425
1.0
14 07 29 16 50
1
43.5844 -112.9686
0.01 0.01
5.0 5.0
./
cdump
1
0
14 07 29 16 50
14 05 14 19 50
0 0 180
1
1.0 1.873 1.0
4.3e-03 0.0 0.0 0.0 0.0
0.0 3.2e+05 5.0e-05
11019.4
1.0e-06
```

Figure 5. HYSPLIT Control File

The above control file simulates a release of cesium-137 from INL at a rate of 52.2 kg/m^3. The release occurred on July 29th 2014 at 4:50 pm. More information on the specifics of the control file are available within Appendix C.

The HYSPLIT *setup.cfg* file, shown in Figure 6, configures how HYSPLIT is to run the control file. It configures the grid parameters for the weather data. These parameters are not changed from run to run within RAVEN.

```
&SETUP
tratio = 0.75,
delt = 0.0,
initd = 0,
kpuff = 0,
khmax = 9999,
numpar = 1000,
maxpar = 1100,
qcycle = 0.0,
efile = ''
kdef = 0,
kzmix = 0,
kbls = 1,
kblt = 2,
isot = -99,
vscale = 200.0,
hscale = 10800.0,
tvmix = 1.00,
tkerd = 0.18,
tkern = 0.18,
kmix0 = 100,
kmixd = 0,
ninit = 1,
ndump = 0,
ncycl = 0,
pinpf = 'PARINIT',
poutf = 'PARDUMP',
mgmin = 10,
conage = 48,
kmsl = 0,
ichem = 0,
cpack = 1,
cmass = 0,
kspl = 50,
krnd = 6,
frhmax = 3.00,
splitf = 1.00,
frhs = 1.00,
frvs = 0.01,
frts = 0.10,
dxf = 1.00,
dyf = 1.00,
dzf = 0.01,
/
```

Figure 6. HYSPLIT setup file.

One of the more powerful tools within HYSPLIT is its ability to output plots of various formats including Keyhole Markup Language (*kml*) files. These files are used by Google earth to read overlays onto their satellite imagery. Figure 7 shows an overlay of a HERON deposition over a Google earth image of the surrounding area.

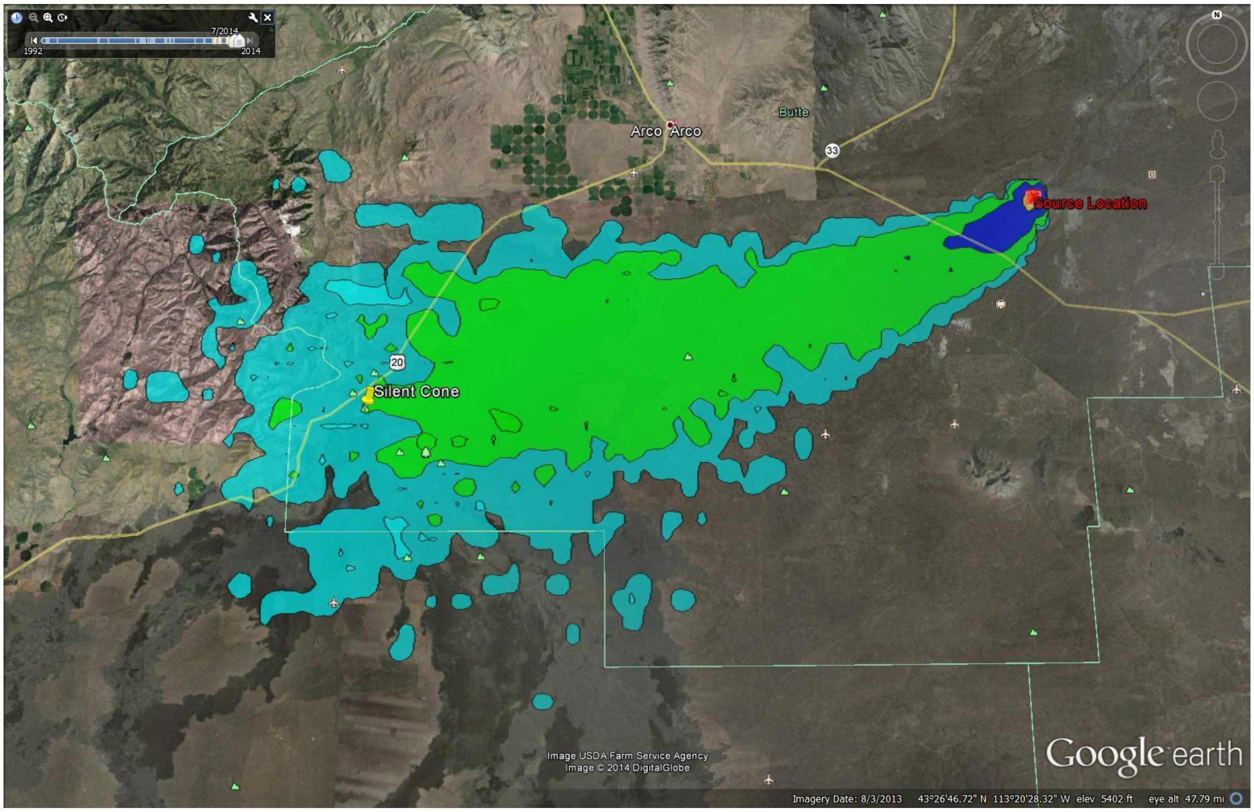

Figure 7. HYSPLIT overlay using Google Earth.

The level of fidelity is unprecedented compared to previous codes. The overlay is joined with the map regardless of how the map view is changed. Figure 8 shows the same map overlay from the perspective of the summit of Silent Cone. This is where the doses were sampled and given back to RAVEN. The discussion on the results of HERON will be discussed in the Results section of this report.

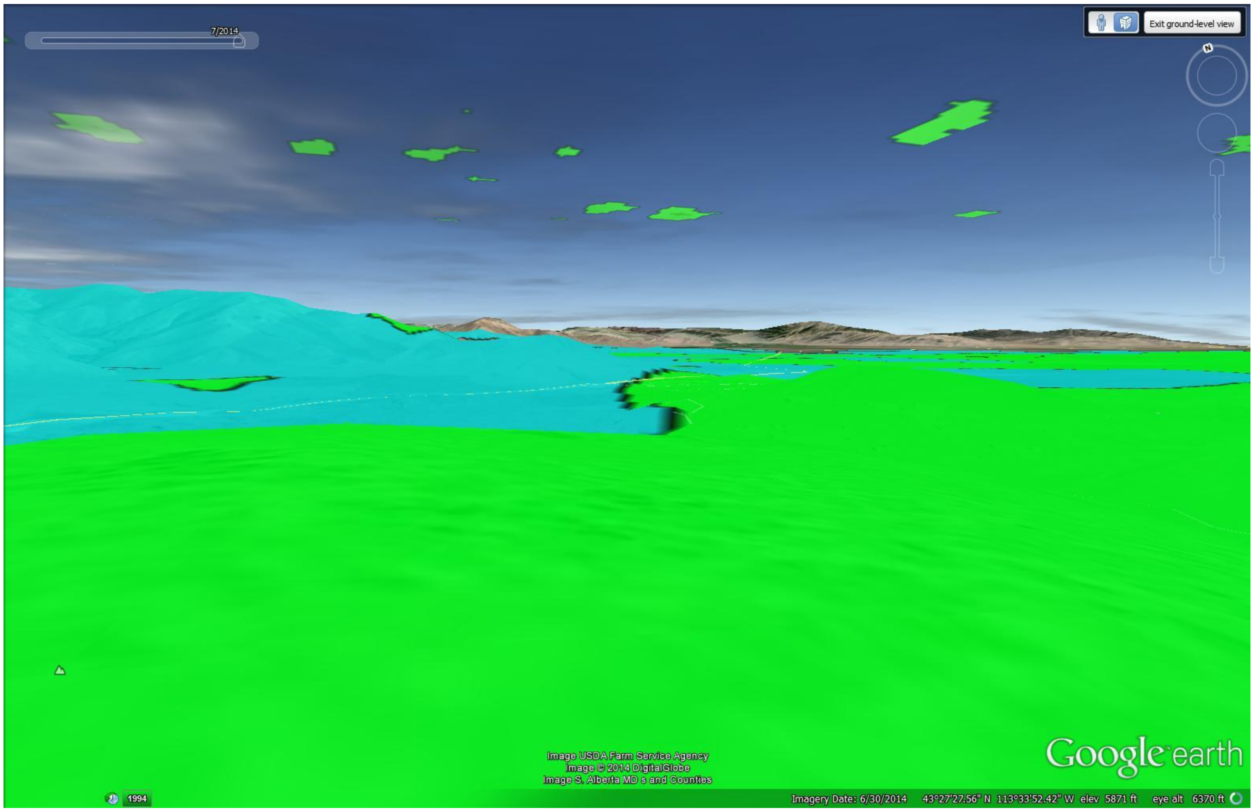

Figure 8. HYSPLIT overlay viewed from Silent Cone Summit.

The ability of HYSPLIT to be able to output the *kml* format also enables other NOAA overlays to all be placed within the same map. This allows the generation of complete weather, deposition and location all to be mapped on a fully controllable three-dimensional viewing platform. Figure 9 shows a combination of Doppler weather radar, current temperature, HYSPLIT deposition and full three-dimensional map of the region with roads and cities highlighted.

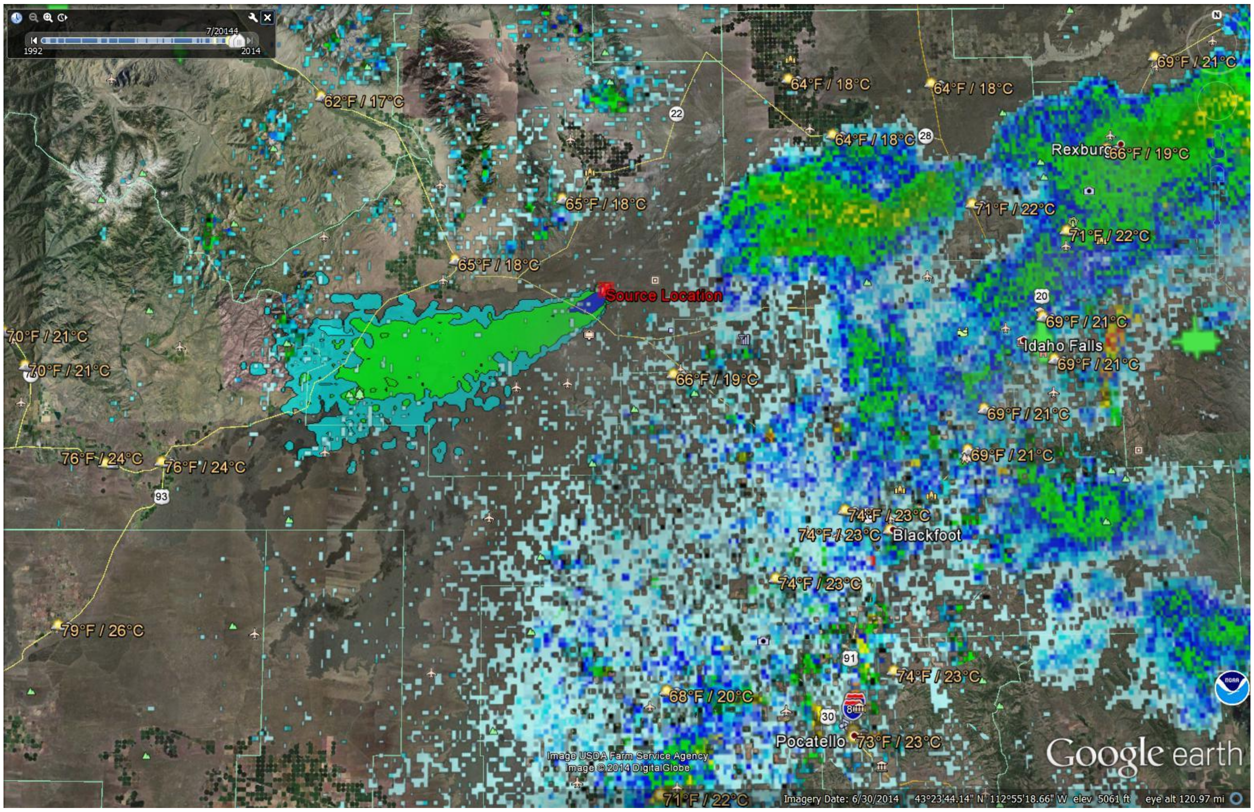

Figure 9. Weather and HYSPLIT deposition overlay.

The HYSPLIT package contains the HYSPLIT code plus many other ancillary codes which are used in conjunction with HYSPLIT. Many of the supplied codes are for plotting and translating the input and output data, they are either used to prepare weather data or to manipulate the output to make it readable in other formats. This is a major feature of HYSPLIT that was utilized in the HERON project and it is another reason for using HYSPLIT within the project.

The integration of HYSPLIT into RAVEN is the centerpiece for the HERON project. Ultimately the goal is to have RAVEN be able to run HYSPLIT thousands, if not millions of times, all the while perturbing the HYSPLIT runs. Each run of HYSPLIT would change certain variables within the problem statement. The demonstration model only changes the source strength of a single cesium-137 source. The source is sampled using a Monte Carlo method on a log-normal distribution. For each consecutive run, RAVEN randomly samples that distribution and provides that selected source strength into the HERON project master script. The script then performs the necessary conversions and runs HYSPLIT with that sampled source strength. The master script then performs the conversion necessary to make the file readable by RAVEN. The process then repeats until the desired number of runs are achieved. This also is lays the ground work for future enhancements since the steps taken by the master script will be needed for any future work because similar translations will need to be made for all perturbations to HYSPLIT.

HYSPLIT has been validated against many real pollutant dispersion scenarios. One example of this was the modeling of a prescribed burning of Butler Block, Western Australia in 2001.[11] Prescribed burns are a common occurrence in many rural areas, the purpose of which is to reduce the amount of fuel that can be consumed during a wild fire. The issue arises when the prescribed burn needs to take place near metropolitan areas. Smoke inhalation from a prescribed burn can still have deleterious health effects on the population living near where these fires occur. An accurate way to predict where a smoke plume would disperse is needed in these situation so that various land management agencies can perform these burns without affecting the health of the local population. These situations are ideal for the validation of HYSPLIT. The Western Australian Department of Conservation and Land Management needed to perform one of these prescribed in Butler Block. A HYSPLIT run was created to simulate how the smoke plume would disperse to see if it would intersect any major population areas and if it did what the pollution fallout would be. The output concentration map (obtained from the reference validation report) for that run are shown in Figure 10.

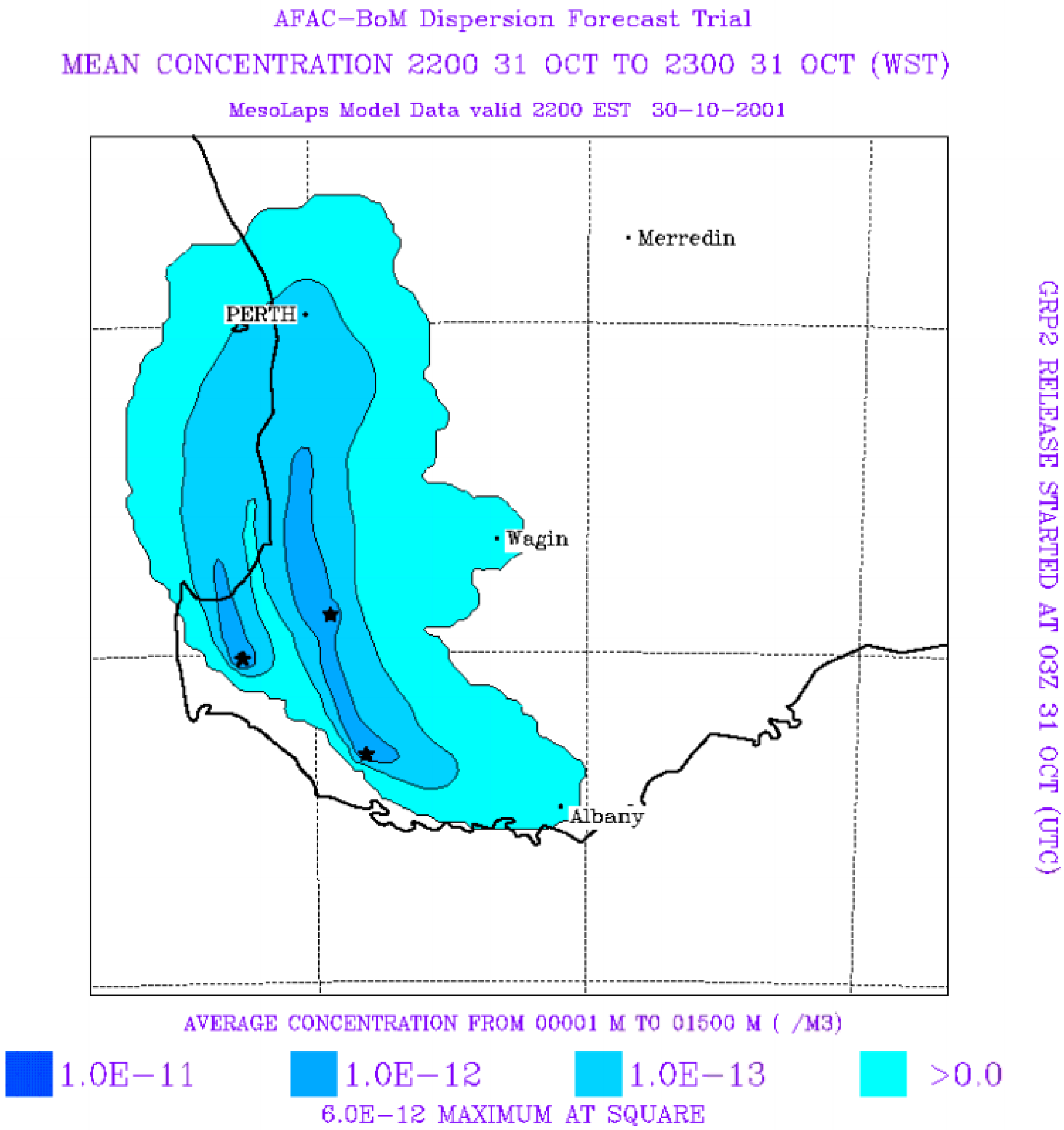

Figure 10. HYSPLIT concentration map from the burning of Butler Block.

The smoke plume was predicted by HYSPLIT to move from the starred locations slightly westward towards the coast and then north towards Perth. Satellite images were taken during the burn and overlaid with the HYSPLIT forecast. After analysis of both the satellite data and observations, it was shown that HYSPLIT had accurately predicted the smoke plume path and subsequent concentration results.

Chernobyl was a major nuclear accident of the 20th century. It has however given researchers ample data to research radiation health effects and nuclide tracking. This provided another validation avenue for HYSPLIT to not only demonstrate pollutant tracking but also radionuclide tracking. A validation study was performed by FNC Technology South Korea in 2007 to compare HYSPLIT tracking of the Chernobyl disaster with real measured data taken throughout Europe.[12] A HYSPLIT model was created to track the cesium-137 release from Chernobyl over a 10 day period from several release heights. The results of the tracked trajectories (obtained from the referenced report) are shown in Figure 11.

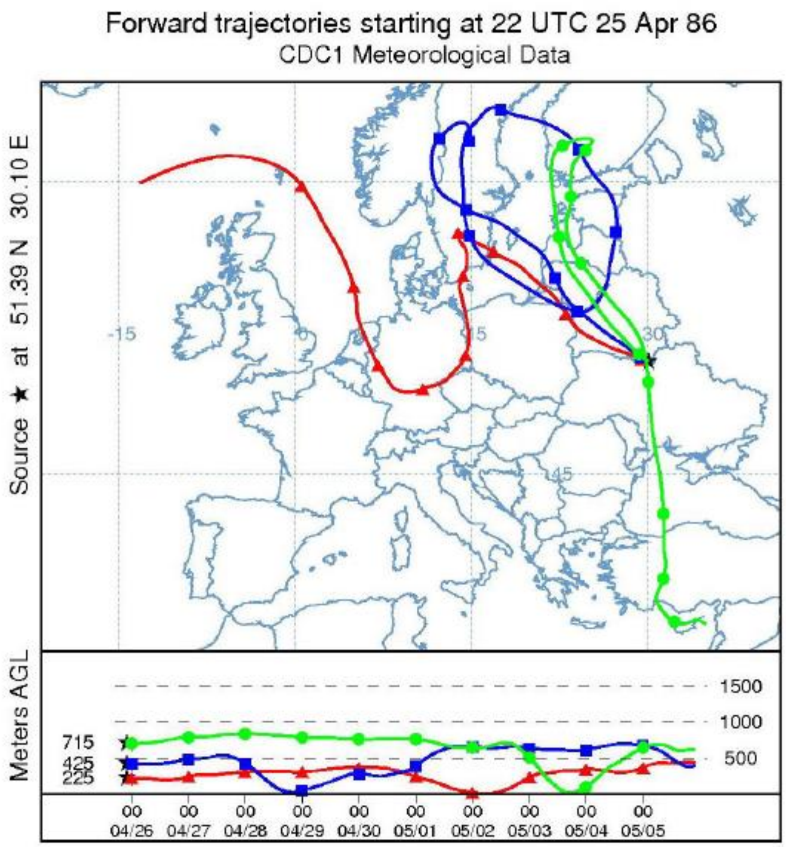

Figure 11. HYSPLIT trajectory map of the Chernobyl release.

After comparison with measured data, the HYSPLIT tracking forecast was shown that it could be used for tracking in emergency type situations but that the quantitative data differed slightly in some measurements and significantly in others. The significant differences were attributed to the uncertainty within the source term of the Chernobyl data. It was the opinion of the authors that despite the long range dispersion and the uncertainties in the source term, HYSPLIT tracking is a valuable tool for characterizing atmospheric release.

6. HERON

HERON is an ISU developed RAVEN-HYSPLIT interface. This interface uses a LINUX shell script which calls the following executable files: *controlmake*, *hycs_std*, *con2rem*, *con2asc*, and *dose*. If a Level-2 PRA had been executed, the result would have been a realistic source term distribution. For this project, an artificial source term distribution is created and sampled by RAVEN which converts it into a *csv* file readable by HYSPLIT using a control file generator program *controlmake.py*. Once the control file is written, HERON then executes HYSPLIT (*hycs_std*) using the input parameters specified in the control file. The output of HYPSLIT is a binary file containing the pollutant concentrations at specified grid points. HERON then calls the executable *con2rem* to convert the concentration file into a dose file at the specified grid points. The output of *con2rem* is a binary file called *rdump*. HERON then calls the executable *con2asc* to convert *rdump* into a readable text format, which is then sent by HERON to a simple python program that extracts the dose information at the specified grid points and converts the information to a comma separated value file (*dose.csv*) which is readable by RAVEN. The HERON process schematic is shown below in Figure 12.

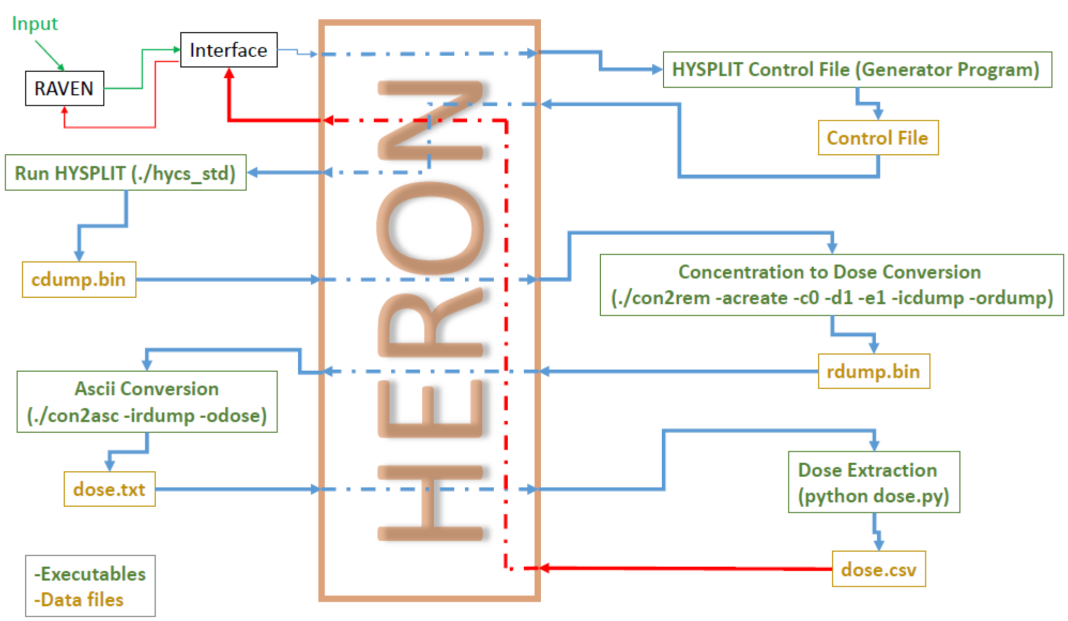

Figure 12. HERON logical flow.

The shell script *pra.sh* runs five executable files. The script is shown below in Figure 13.

```
#!/bin/sh                                   # path where the shell executable file is located
clear                                       # clears the screen
pwd                                         # (print working directory) outputs path of current working directory
cd ..                                       # up one directory
python controlmake.py                       # makes control file
./hycs_std                                  # executes HYSPLIT
./con2rem -acreate -c0 -d1 -e1 -icdump -ordump  # dose conversion
./con2asc -irdump -odose                    # converts binary file to ascii
python dose.py                              # extracts dose info from ascii file
```

Figure 13. *pra.sh* code.

The need for the fourth line in the code, "*cd ..*", comes from the fact that a folder called *GetSource_MC* is created inside HERON by the RAVEN interface and when executing HERON the necessary files in that folder are actually one directory back. So, with this command the path is changed back to where the HERON files are located.

pra.sh starts first with executing a python script *controlmake.py*, (Appendix F). This basically takes *ravenout.csv* as an input file and then creates the CONTROL file. All of the parameters needed to execute HYSPLIT are located in this control file. A detailed description of all the parameters within the control file can be found in Appendix C at the end of this report.

The shell script accesses the directory where the HYSPLIT related scripts are stored and then runs the necessary programs for HYSPLIT to output a dose. RAVEN's sampled source term is passed to HYSPLIT through a Python script. This code takes a source term value of the form mass per hour from a RAVEN generated *csv* file and uses that to generate the HYSPLIT CONTROL file which HYSPLIT uses to set the parameters of the simulation. The source from RAVEN is assumed to be a number representing the mass of cesium-137 released per hour from the site. Currently, the code tells HYSPLIT that the release lasts for one hour.

The cesium-137 particles were taken to have a diameter of 1.0 μm, referencing work from the Journal of Environmental Radioactivity.[13] The ground deposition velocity of the particles was taken to be 4.3E-3 m/s, using work from Takeyasu and Sumiya.[14] Other values in the code are those recommended by the HYSPLIT users guide or through conversations with the HYSPLIT developers, see Appendix C.

After the HYSPLIT CONTROL file is generated by the python script *controlmake.py*, the shell script *pra.sh* runs the HYSPLIT executable *hycs_std*. This executable requires the weather data *ARWDATA.BIN* and *ARWDATA.BIN20*, and the CONTROL and SETUP files which were generated earlier. It outputs a file *cdump* which contains the dispersion data. The weather data associated with this example is very detailed and specific to the assumed location. Detailed weather data is an essential aspect of an effective HYSPLIT simulation. A listing of general weather data for U.S. NPPs is provided in Appendix D. Significantly more detailed weather data will be necessary for a U. S. NPP accident simulation.

Executing HYSPLIT outputs a binary file containing the concentration information at specific locations. The binary file, *cdump.bin*, is then converted to a dose using a program called *CON2REM,* which converts the concentration data to a dose at that specific point. In *CON2REM*, the output result is a dose measured in rem, assuming an input source in kg. A breathing rate for the inhalation dose is taken to be 0.925 m^3/hr. *CON2REM* calculates the dose due to the exposure using the specified concentration at that grid point.

Internal and external doses are calculated independently, then summed and averaged over the sampled time frame. The exposure portion of the dose includes the effective dose equivalent from cloud shine and deposition (ground shine and a particle re-suspension). The inhalation dose is calculated using an acute (30-day) bone marrow inhalation dose, an acute lung inhalation dose, a committed dose equivalent (CDE) thyroid inhalation dose, a 50-year committed effective dose equivalent (CEDE), a total acute bone dose, and a total acute lung dose. A total effective dose equivalent (TEDE) is then determined using the 50-year inhalation CEDE, the effective cloud shine, and the effective ground shine. *CON2REM* then records the TEDE in a binary dose file named *rdump.bin*.

The *rdump* binary file is then converted to a simple ASCII file composed of one record per grid point for all grid points where doses are non-zero using the program *CON2ASC*. Doses for multiple levels and pollutant species are all listed on the same record for each grid point. The main purpose for this conversion is to create a file that can be imported into other applications. An illustration of the output is shown in Figure 14 for a sample dose simulation.

DAY	HR	LAT	LON	CS3700000
210	19	43.46	-113.78	2.10E-02
210	19	43.45	-113.76	1.10E-02
210	19	43.46	-113.76	1.10E-02
210	19	43.45	-113.75	1.10E-02
210	19	43.46	-113.75	1.10E-02
210	19	43.45	-113.74	1.10E-02
210	19	43.46	-113.74	1.10E-02
210	19	43.39	-113.73	1.00E-02
210	19	43.45	-113.73	1.10E-02
210	19	43.55	-113.73	2.20E-02
210	19	43.45	-113.71	1.10E-02
210	19	43.48	-113.71	2.10E-02
210	19	43.49	-113.71	1.00E-02
210	19	43.51	-113.71	1.10E-02
210	19	43.54	-113.71	1.10E-02
210	19	43.47	-113.7	1.10E-02
210	19	43.5	-113.7	2.10E-02
210	19	43.39	-113.69	1.00E-02
210	19	43.42	-113.69	1.10E-02
210	19	43.48	-113.69	7.90E-03
210	19	43.5	-113.69	2.20E-02

Figure 14. Dose.txt file which is the output of CON2ASC program.

Once the doses at specified grid points are established, the data needs to be extracted and rewritten in a form RAVEN can read. *dose.py* is a simple python code that extracts the dose information from a text file (*dose_210_19.txt*) and writes the contents into csv format (*dose.csv*). The text file containing the dose information also contains the longitude and latitude information as to where the dose was measured. The HYSPLIT source input information is also called and written to *dose.csv* by running *dose.py*. A line-by-line description of *dose.py* is shown in Figure 15.

```
#!/usr/bin/python                                   # makes code compatible across all platforms
import csv                                          # creates table-like custom objects from the items in CSV files
f=open('dose_210_19','r')                           # opens file containing dose information
h=open('ravenout.csv')                              # opens HYSPLIT input file containing source information
sourcel=h.readlines()[-1]                           # reads source
lines=f.readlines()                                 # reads dose information
tom = lines[-18]                                    # picks a location to measure dose
strn = tom                                          # places in string
string=tom.split()                                  # splits string to separate dose, long, and lat
lon = string[-3]                                    # longitude is 3rd from last in string
lat = string[-2]                                    # latitude is 2nd from last in string
dose = string[-1]                                   # dose is last in string
f.close                                             # closes dose file
with open('GetSource_MC/dose.csv', 'w') as fp:      #
  a = csv.writer(fp, delimiter=',')                 # writes longitude, latitude, dose, source into csv file
  data = [lon,lat,dose,sourcel,"1.0"]               #
  datas = ["lon","lat","dose","source","dummy"]     # "dummy" is added to help RAVEN read dose.py
  a.writerow(datas)                                 #
  a.writerow(data)                                  #
```

Figure 15. Python code *dose.py* used to extract dose data at a specific location.

The HYSPLIT/RAVEN interface module *HYSPLIT_INT* is an object class wherein RAVEN specific named methods are specially coded to work specifically with HYSPLIT. It is written in python. The executable pra.sh has been written to initiate a HYSPLIT run and modify the output to be sent back to RAVEN for post-processing. These files, *pra.sh*, and *ravenout.csv*, are originally passed into RAVEN through the xml script *HYSPLIT_RUN*. The defined methods or functions as shown in Figure 16 are called by RAVEN as the simulation is run. For future improvement, the pra.sh file and the *HYSPLIT_INT* file will need to be better merged to avoid duplication of functionality. The current computational structure was chosen to make a simple link in a short amount of time.

```
from __future__ import division, print_function, unicode_literals, absolute_import
import warnings
warnings.simplefilter('default',DeprecationWarning)

import os
import copy
import shutil

class HYSPLIT_INT:      # HYSPLIT/RAVEN interface module
  def generateCommand(self,inputFiles,executable):
      #method to generate execution of HYSPLIT using passed input files and
      #the HYSPLIT executable file, pra.sh.
      #self is the instance of this class created upon execution of HYSPLIT_RUN.xml
    executeCommand = executable
    outputfile = "dose"
    return executeCommand,outputfile

  def createNewInput(self,currentInputFiles,oriInputFiles,samplerType,**Kwargs):
      #method used to write RAVEN sample variable values into input file for
      #successive runs. Dictionary set up for versatility in the choice of sampler
      #types for future implementations.
    self._samplersDictionary = {}
    self._samplersDictionary['MonteCarlo'        ] = self.pointSamplerForExampleCode
    self._samplersDictionary['LHS'               ] = self.pointSamplerForExampleCode
    self._samplersDictionary['Grid'              ] = self.pointSamplerForExampleCode
    self._samplersDictionary['Adaptive'          ] = self.pointSamplerForExampleCode

    modifDict = self._samplersDictionary[samplerType](**Kwargs)
    key,value=modifDict.keys()[0],modifDict.values()[0]
    hysplitopen=open(os.path.split(currentInputFiles[0])[0]+"/ravenout.csv",'w')
    hysplitopen.write(str(value))
    hysplitopen.close()
    return currentInputFiles

  def pointSamplerForExampleCode(self,**Kwargs):
      #method used to specialize sampler dictionary
      modifDict={}
      for var in Kwargs['SampledVars']:
          value=Kwargs['SampledVars'][var]
          modifDict[var]=Kwargs['SampledVars'][var]

      return modifDict
```

Figure 16. *HYSPLIT_INT.py* source code.

RAVEN is controlled by an *xml* file, HYSPLIT_RUN, which tells RAVEN the details of the desired distribution, how to call HYSPLIT, and how the output is to be managed. The following paragraphs describe the code for HYSPLIT_RUN in Figure 17.

This *xml* file interfaces with different RAVEN modules by using *xml* tags corresponding to python files in the RAVEN framework.

The <Simulation> tag encloses the RAVEN run by calling on *Simulation.py* and passing it the desired parameters of the run.

The <RunInfo> section sets the directory in which RAVEN runs (working directory), the external files with which RAVEN will interact, the name of the RAVEN run, and the number of batches to be run.

The <Models> section interfaces with *Models.py.* This is where the model RAVEN is to run is specified. To run the other sections of HERON, RAVEN needs to be told to look at *HYSPLIT_INT.py* and to execute the *pra.sh* script. These commands are grouped together into a RAVEN Model named 'My_HYSPLIT' which is run in the <Steps> section.

In the <Distribution> section the distribution that RAVEN needs to sample is defined. For the code shown (Figure 17) a lognormal distribution was chosen with a lower bound of 1.0 and an upper-bound of 100.0, a mean of 30.0, and a sigma of 15.0. The distribution name ('Source_Term') allows this distribution to be called by the other sections of the code.

<Samplers> defines the method RAVEN will use to sample its given distribution. For this work, a MonteCarlo sampler was chosen to randomly sample the above distribution ten times. Each sample needs to have a defined variable name which allows the sampled value to be passed elsewhere in the code. In this case, each time RAVEN generates a sampled value, it sends it to the HYSPLIT-RAVEN interface file *HYSPLIT_INT.py* which writes the sampled value to *ravenout.csv* allowing the construction of the CONTROL file for HYSPLIT (see section on controlmake.py).

The <Datas> section reads in the data from *dose.csv* generated by the other parts of HERON, specifically the rows under the 'source' and 'dose' headings.

In <Steps> the specific sections needed to run are called. The name of the MultiRun must match the name set under <Sequence> in the <RunInfo> section. This creates a working folder for RAVEN to store the results of each run before overwriting those results in the next run. RAVEN requires that there be an input file in existence even if it does not need any data from it. The blank file *something.i* was created for this purpose and stored in the working directory. RAVEN is pointed to this file in this section.

<OutStreamManager> manages the output of RAVEN. After RAVEN has executed the code defined in the <Model> section, which runs HYSPLIT, it reads the dose data from *dose.csv* in the <Datas> section. RAVEN can then use these values to produce a plot or otherwise allow visualization of the data. In this code, the data of the ten runs is ouput as a *csv* and plotted using RAVEN. For the *csv* output, the name of the file is defined and the source of the data to be output. In this code, the <source> is the set 'DoseDist' defined in the <Datas> section. For plotting, RAVEN combines python with a MatLab plotter, and the parameters of the desired plot are defined under the <plot> tags. Here, the type of plot is specified and the data to be plotted on the axes. The <actions> tag tells the plotter how to print the graph; in this instance as a *jpeg* to the screen.

```xml
<?xml version="1.0" encoding="UTF-8"?>
<Simulation>
    <RunInfo>
        <WorkingDir>/home/pra/moose/src/trunk/raven/framework/ISU</WorkingDir>
        <Files>something.i,ravenout.csv</Files>
        <Sequence>GetSource_MC</Sequence>
        <batchSize>1</batchSize>
    </RunInfo>
<Models>
    <Code name='My_HYSPLIT' subType='HYSPLIT_INT'><executable>pra.sh</executable></Code
</Models>
<Distributions>
    <LogNormal name='Source_Term'>
        <upperBound>100.0</upperBound>
        <lowerBound>1.0</lowerBound>
        <mean>30.0</mean>
        <sigma>15.0</sigma>
    </LogNormal>
</Distributions>
<Samplers>
    <MonteCarlo name='TestRun' initial_seed='52' limit='10'>
      <variable name='Source'>
        <distribution>Source_Term</distribution>
      </variable>
      </MonteCarlo>
</Samplers>
<Datas>
    <TimePointSet name='DoseDist'>
        <Input>source</Input>
        <Output>dose</Output>
   </TimePointSet>
</Datas>
<Steps>
    <MultiRun name='GetSource_MC' pauseAtEnd='True'>
        <Sampler class='Samplers'         type='MonteCarlo'      >TestRun</Sampler>
        <Input   class='Files'            type=''                >something.i</Input>
        <Model   class='Models'           type='Code'            >My_HYSPLIT</Model>
        <Output  class='Datas'            type='TimePointSet'    >DoseDist</Output>
        <Output  class='OutStreamManager' type='Print'           >out1</Output>
        <Output  class='OutStreamManager' type='Plot'            >Dose_Distribution</Output>
    </MultiRun>
</Steps>
<OutStreamManager>
    <Print name='out1'>
        <type>csv</type>
        <source>DoseDist</source>
    </Print>
    <Plot name='Dose_Distribution'  dim='2' overwrite='True'>
        <plotSettings>
            <plot>
                <type>scatter</type>
                <x>DoseDist|Input|source</x>
                <y>DoseDist|Output|dose</y>
            </plot>
            <xlabel>Source</xlabel>
            <ylabel>Dose</ylabel>
        </plotSettings>
        <actions>
            <how>jpeg,screen</how>
            <title><text>Dose Distribution</text></title>
        </actions>
    </Plot>
</OutStreamManager>
</Simulation>
```

Figure 17. *HYSPLIT_RUN.xml* source code.

7. Results

The main objective of the project was to couple HYSPLIT to RAVEN and generate a dose distribution plot. The objective was met with a successful generation of plots from RAVEN using HYSPLIT pollutant tracking. The RAVEN runs were performed on a variety of machines; the run demonstrated in the results was created using an ISU HPC called Lithium. The post processing and plotting of data using Matlab, Google Earth and HYSPLIT ancillary utilities were performed on other machines.

The following figures show the meteorological data HERON used for the cesium release. The map is centered on the southern half of Idaho.

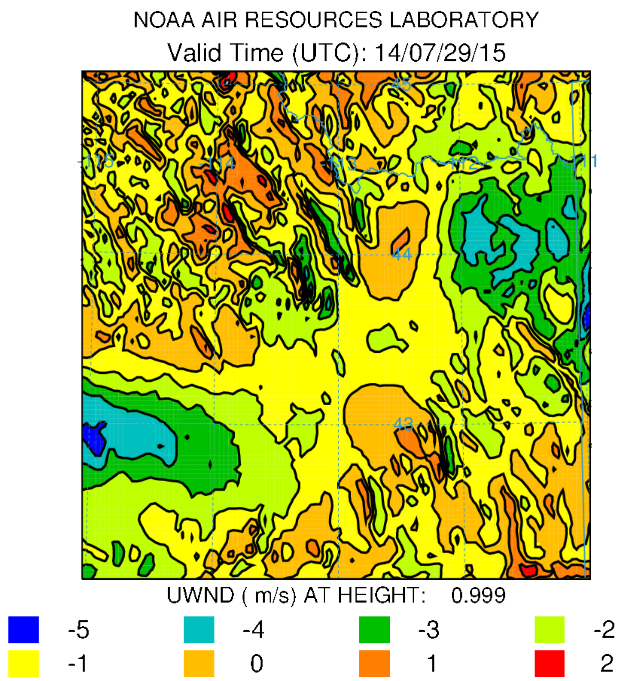

Figure 18. U component of the wind.

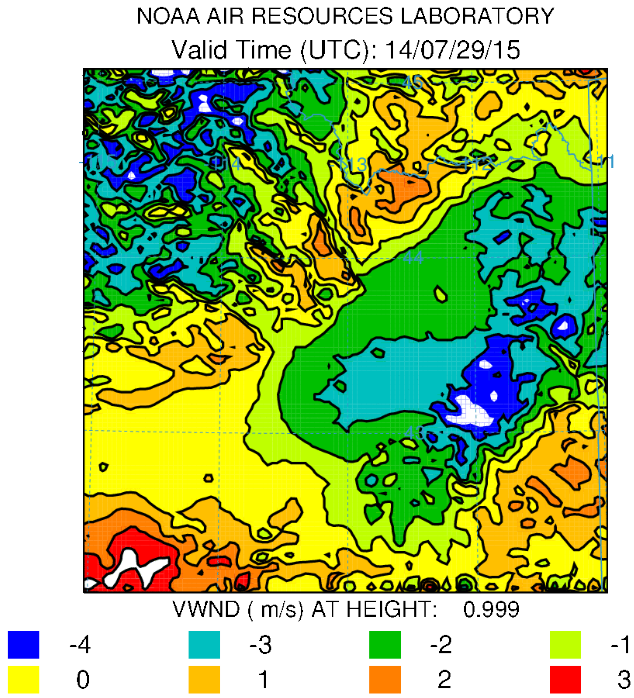

Figure 19. V component of the wind.

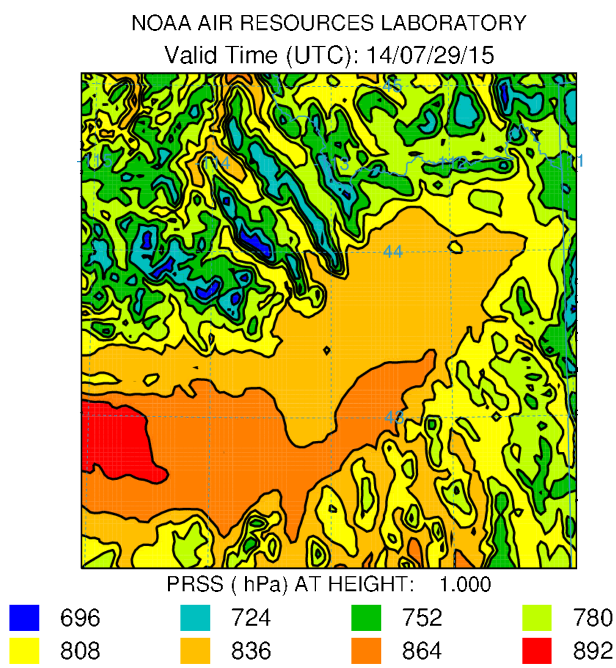

Figure 20. HYSPLIT pressure map.

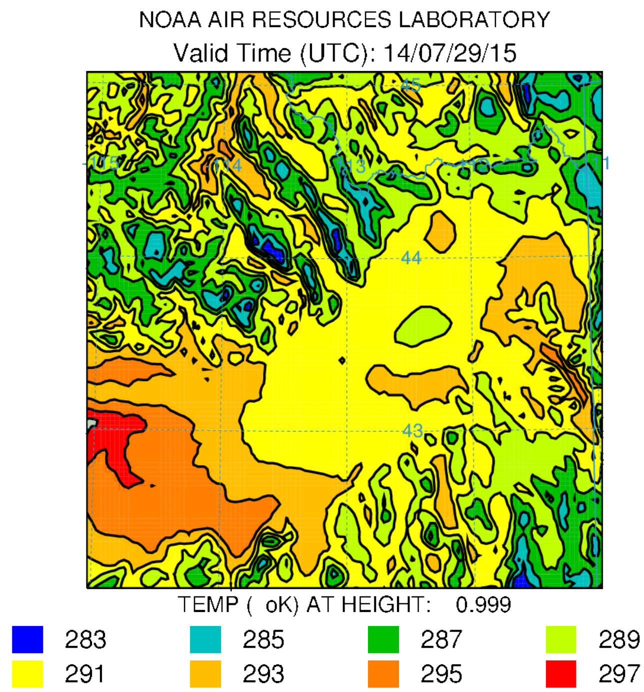

Figure 21. HYSPLIT temperature map.

The simulated release of cesium-137 is located at the GPS coordinates latitude 43.5844 N by longitude 112.9686 W. This location is the southwest corner of the INL ATR complex. Figure *22* shows the source location highlighted in red. This point is generated by HYSPLIT and then imported into Google Earth. The Silent Cone thumbtack was an addition from Google Earth.

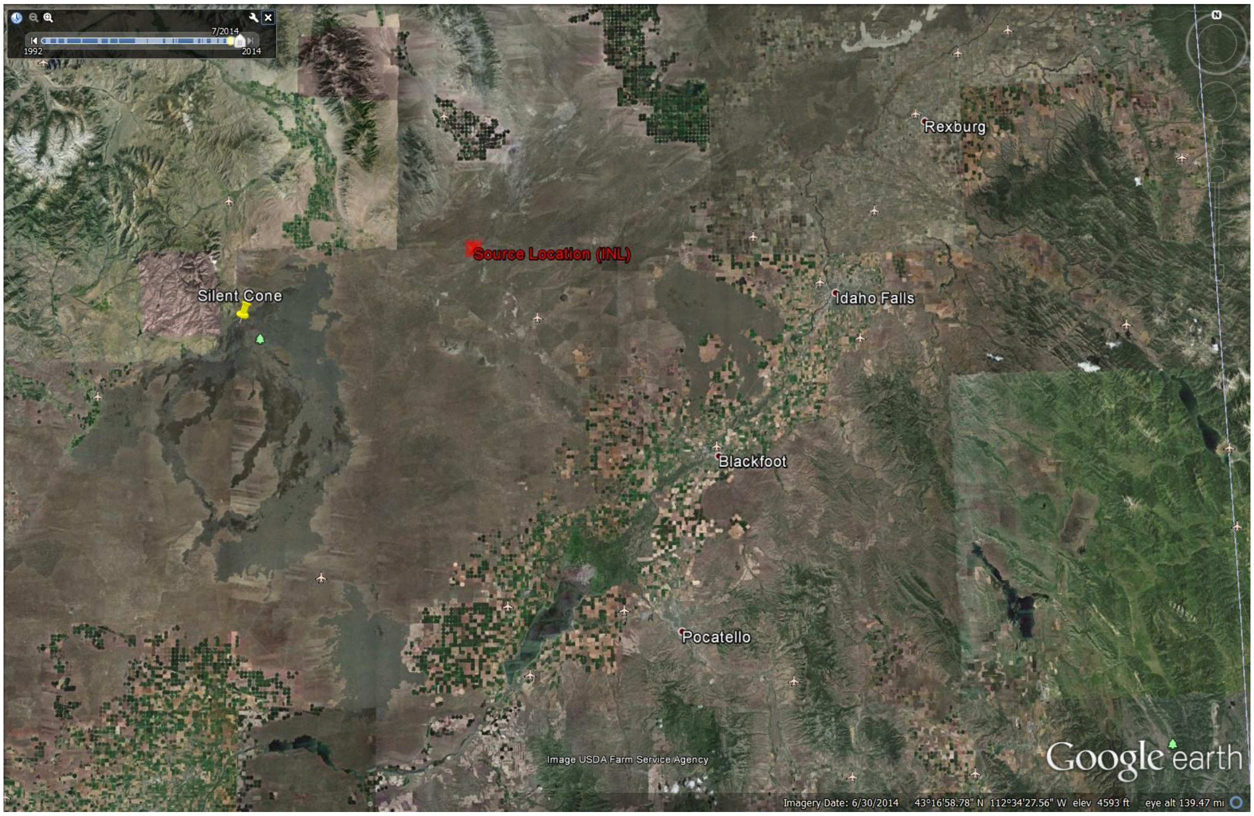

Figure 22. Source location in Google Earth.

The RAVEN run is initialized by the Linux command:

python ../../framework/Driver.py HYSPLIT_RUN.xml.

RAVEN then runs continuously calling the *pra.sh* script. With each RAVEN call of the *pra.sh* script, HYSPLIT is executed with a revised input file. Following the RAVEN prescribed number of calls, RAVEN generates the resulting dose distribution plot. During the RAVEN run a dose distribution plot is generated live as the points are generated from HYSPLIT. An example of the RAVEN run plus the plot are shown in Figure 23.

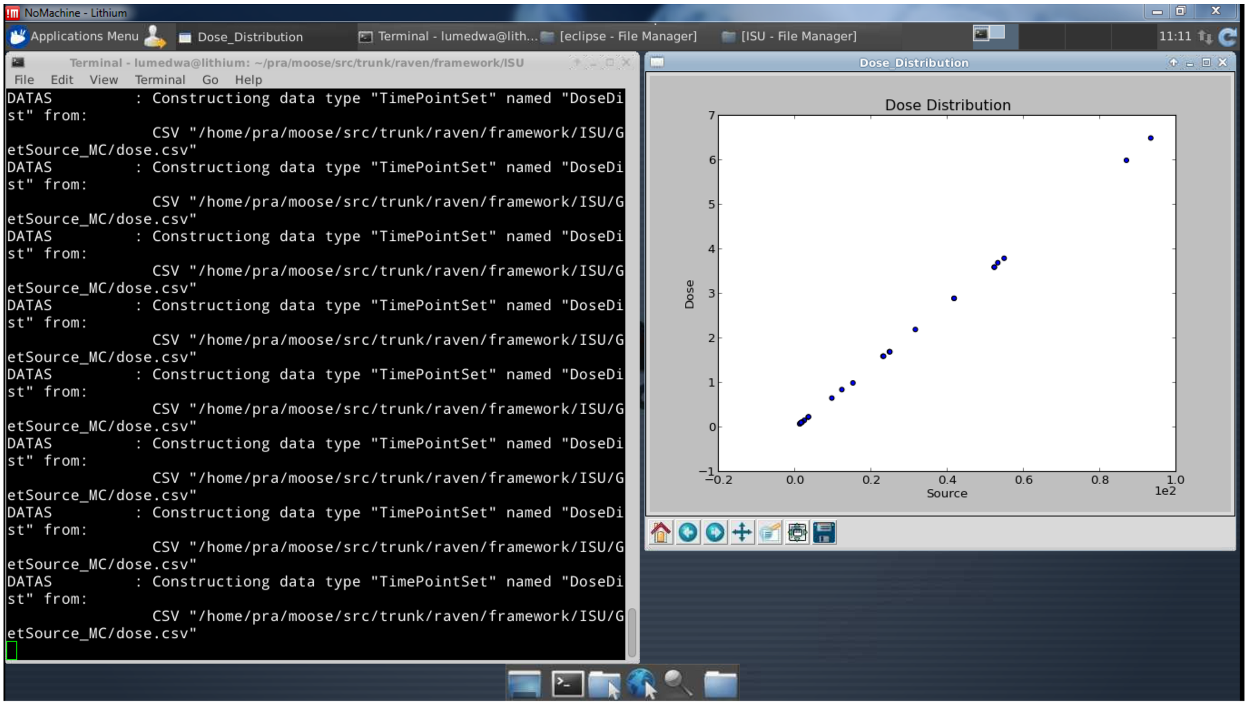

Figure 23. Lithium screenshot of RAVEN run and plotting.

The following figures are the plotted results from one of the HYSPLIT runs. The plots were generated from the *cdump* file created by HYSPLIT and then run through a HYSPLIT ancillary program called *concplot* which is what generated Figure 24. The figure shows the deposition of cesium-137 concentration at ground-level. The plot by itself does not convey how long or large the tail is because the only reference of scale given is longitude and latitude. The reason for this is that HYSPLIT calculates everything using GPS coordinates which come from the grid which is defined in the setup and control files. The order of magnitude of the concentration is shown in the legend. The reason it is only order of magnitude is to make the plot easier to read. The actual results are reported to several significant digits. This information is contained in the *cdump* file.

Figure 25 projects an averaged trajectory path of the release. The trajectory plot is a clear demonstration of why Lagrangian tracking is superior to straight-line Gaussian model. The averaged trajectory has three major changes in direction that would have not been calculated by straight-line Gaussian model. The Guassian model would have calculated the plume to travel almost perpendicular to the real plume travel. The average trajectory was plotted using a similar tool to *concplot* called *trajplot*. The various HYSPLIT plotting programs all have the ability to output the *kml* language files which allows the results to be plotted into Google Earth.

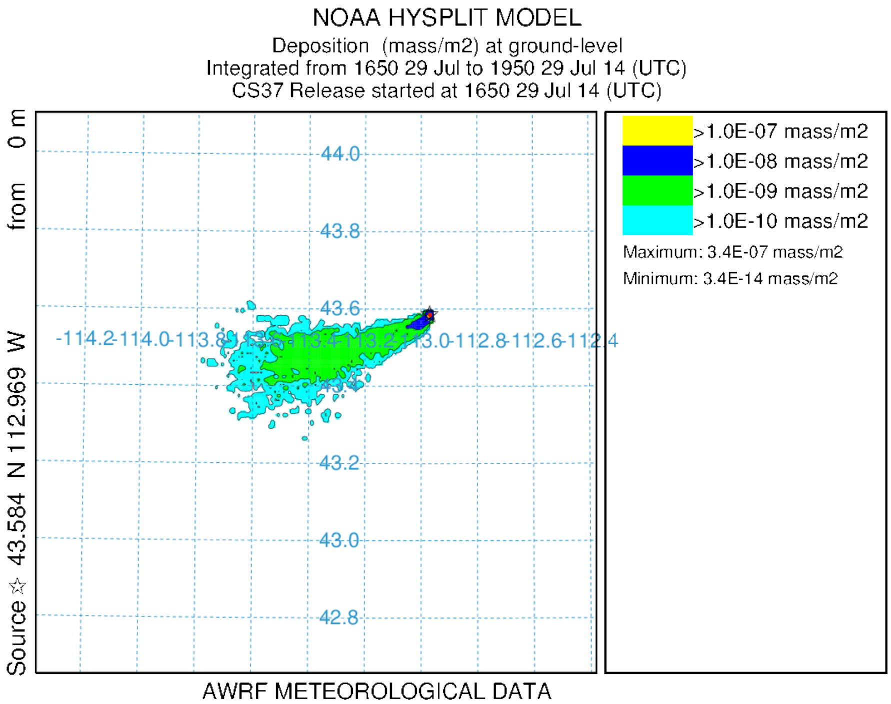

Figure 24. HYSPLIT deposition map.

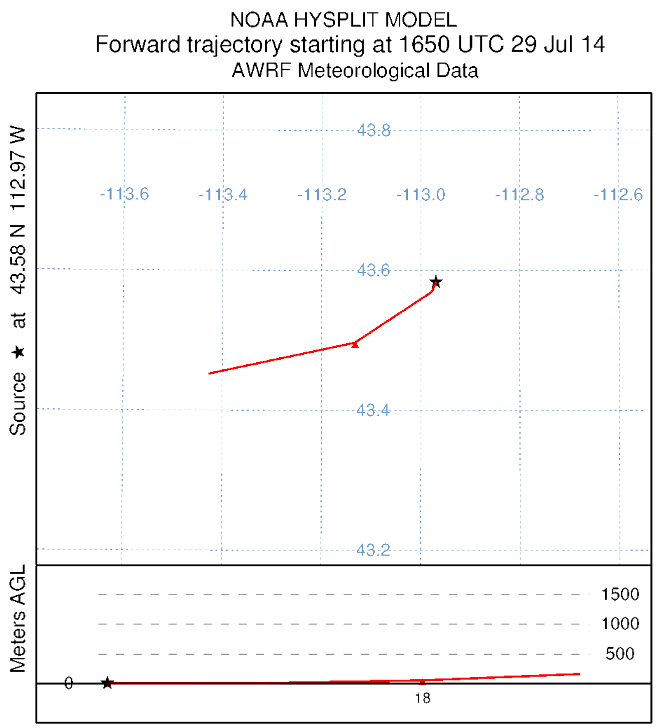

Figure 25. HYSPLIT trajectory map.

The following figures are the HYSPLIT deposition overlays onto Google Earth maps. Figure 26, Figure 27 and Figure 28 show the HYSPLIT run results overlaid onto Google Earth. It should be noted that the overlays are not simple extrapolations of a picture onto another picture, Google Earth is reading the HYSPLIT *kml* files and plotting the quantitative deposition onto the map. The above images are the real concentration results plotted exactly via GPS coordinates onto scale maps. This is highly important because it gives an accurate prediction of deposition across real maps. This allows emergency planners to make better decisions as to how to respond to an emergency situation like a cesium-137 release. It is also the reason why HYSPLIT is such a valuable tool to use for large scale radioactive material releases.

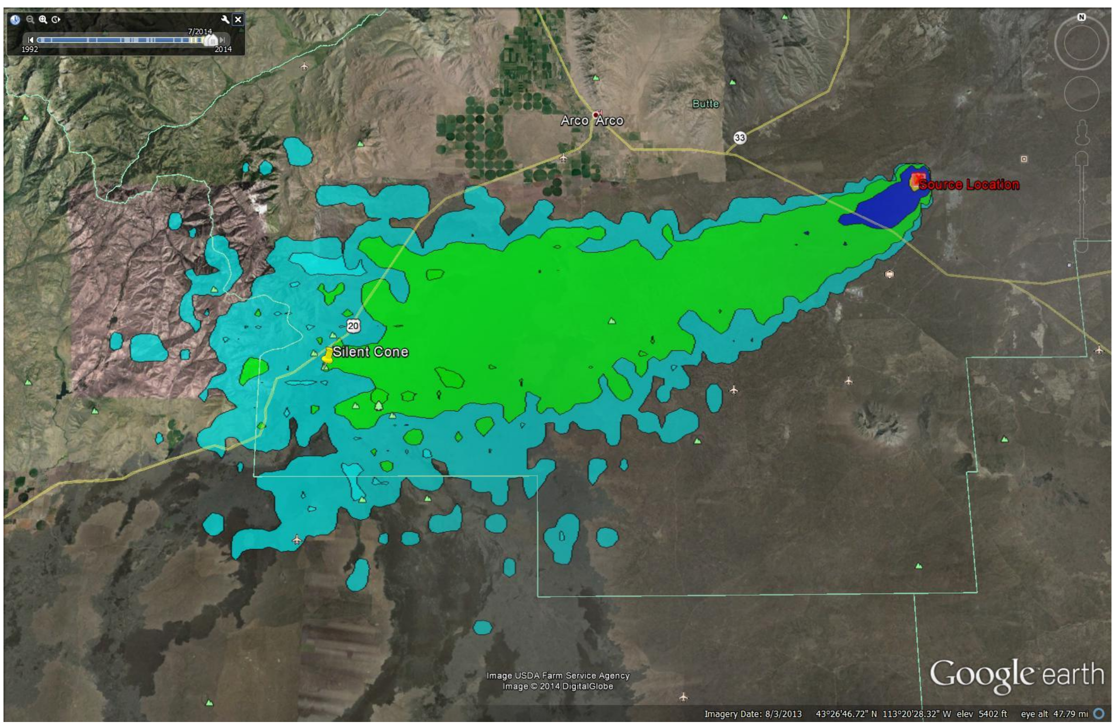

Figure 26. HYSPLIT deposition map overlay onto Google Earth.

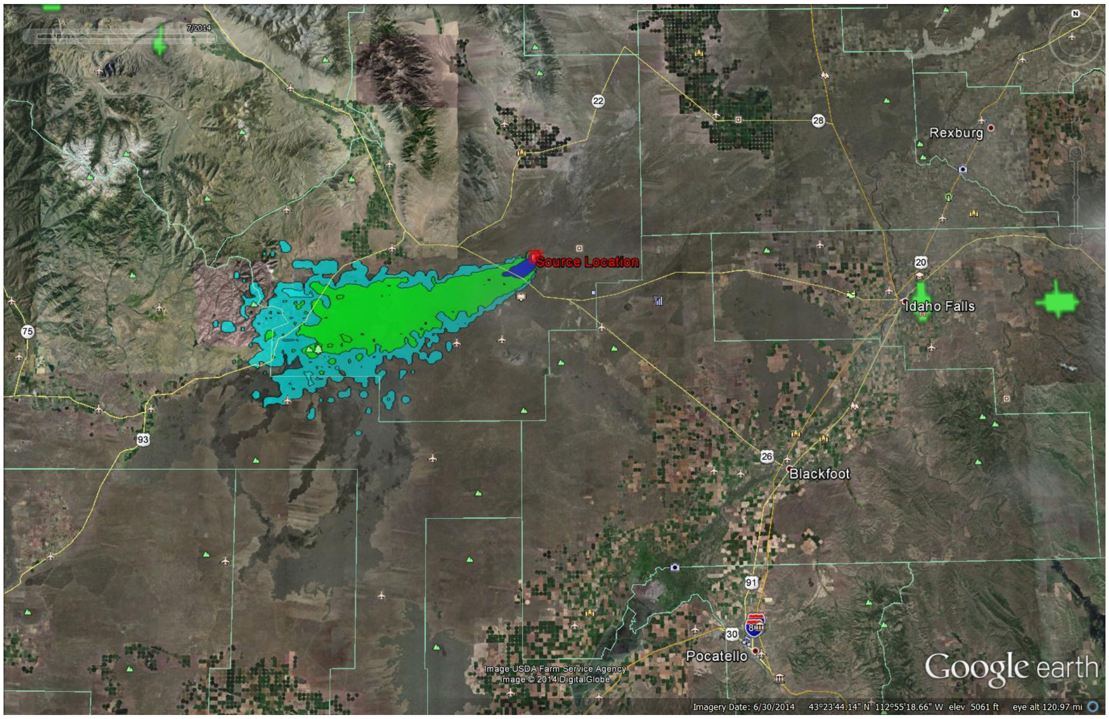

Figure 27. HYSPLIT deposition overlay onto Google Earth (zoomed out).

Figure 28. HYSPLIT deposition overlay onto Google Earth (state view).

Figure 29 represents the achievement of the goal for the HERON project. The data in the figure above is the successful run of HYSPLIT 100 times with HERON performing the HYSPLIT runs and dose calculations and RAVEN generating the input and reading the output data to generate the above plot. The above plot is an important demonstration of the power of coupling RAVEN and HYSPLIT to predict results which has not previously been achieved. The plot shows a distribution of doses with their starting source strength gathered at the Silent Cone summit. The reason the graph is linear is because the only value that was perturbed was the source strength. The actual transport, albeit very complicated, was not changed. What can be noticed is how the data is more clustered at the low end, demonstrating the lognormal nature of the source strength. This plot is only one point using one source strength in a gridded field of nearly 1000 points, the actual data generated could make distribution plots like Figure 29 for each of the 1000 points and for each of the 100 runs of HYSPLIT. For demonstration purposes of HERON, we chose only one point, the Silent Cone Summit with 100 samples of the source distribution. To make the following graphs appear clearer, HYSPLIT was run, using RAVEN, 1000 to 5000 times. This took between 30 minutes and 3 hours.

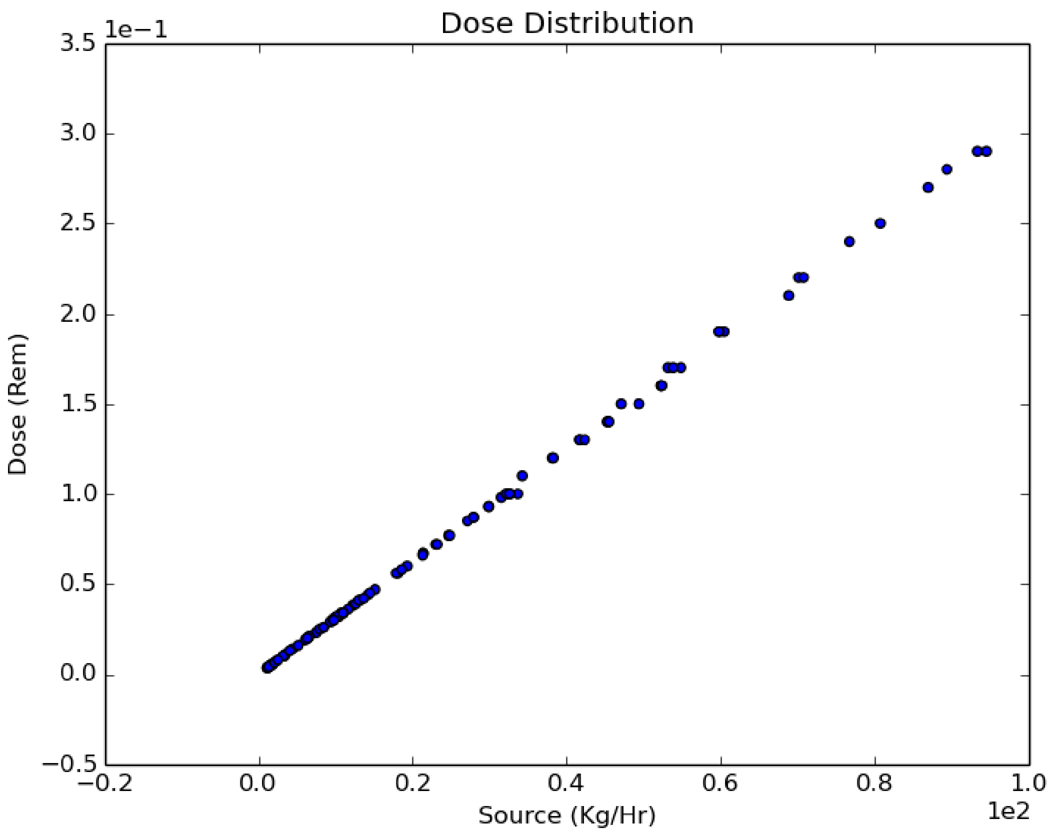

Figure 29. RAVEN dose distribution at Silent Cone Peak.

Figure 30 is a demonstration of how HERON could move further in development. The figure shows the same run from Figure 29 only plotted as a histogram of how often certain doses happen. The reason this is useful is because a run could be setup with particular parameters in mind and then used to generate the above plot in RAVEN to predict how probable it is to exceed a certain dose limit. For demonstration purposes, a ficticious regulatory limit was placed at 0.175 rem. This has a large impact on how Level-3 PRA can be performed and what kind of data can be created. The above plot was created using MATLAB although RAVEN also has the ability to generate similar plots. The source code for the MATLAB plotting is included in Appendix E.

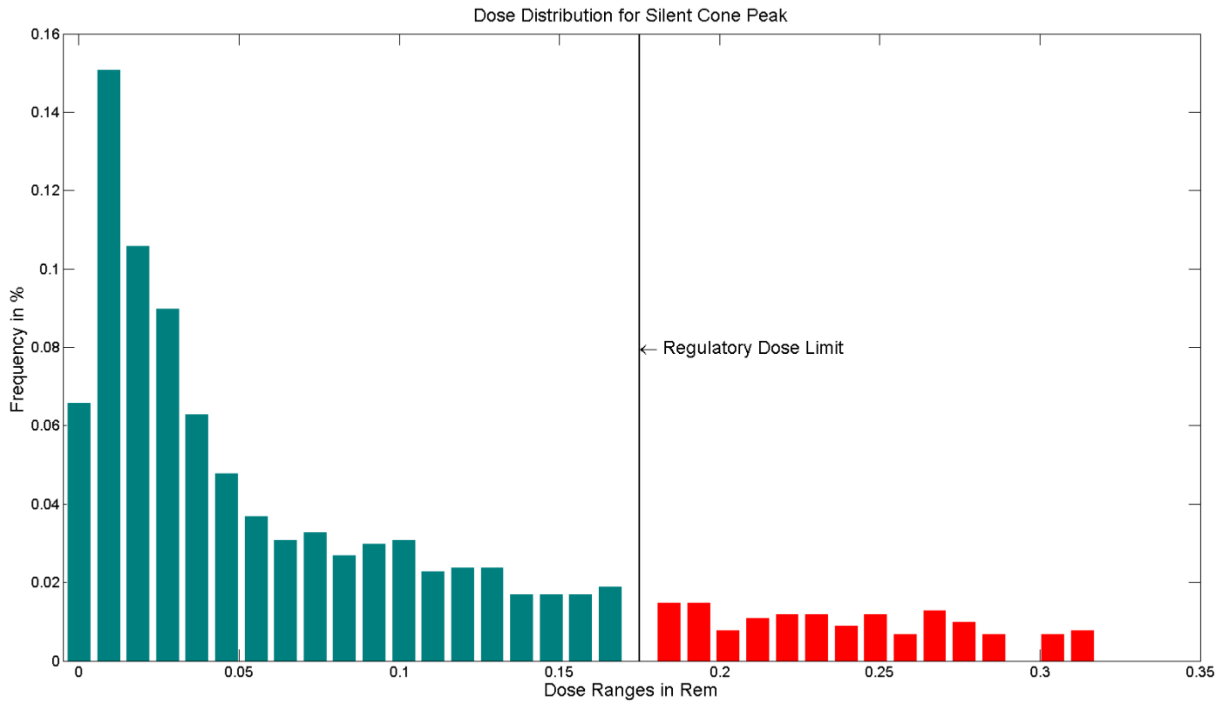

Figure 30. Matlab post processing 1000 sampled sources using lognormal distribution.

The following figures show the versatility of RAVEN and HERON by changing the run parameters. Figure *31* is the same run as Figure *30* but running 5000 samples of the source distribution and Figure *32* is using a normal distribution of 1000 samples.

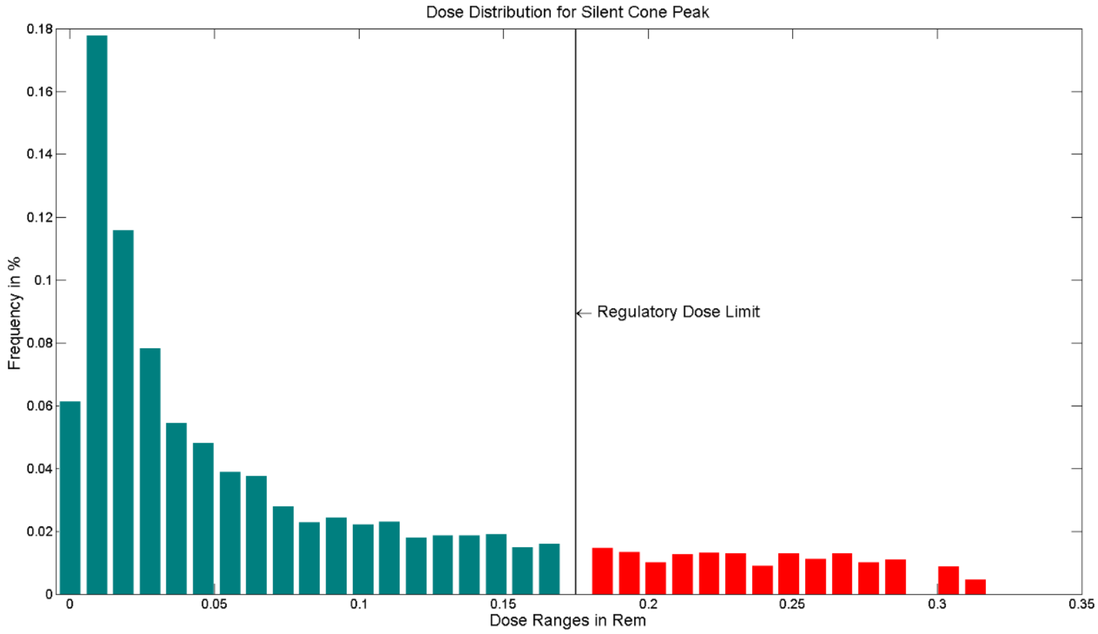

Figure 31. Matlab post processing 5000 sampled sources using lognormal distribution.

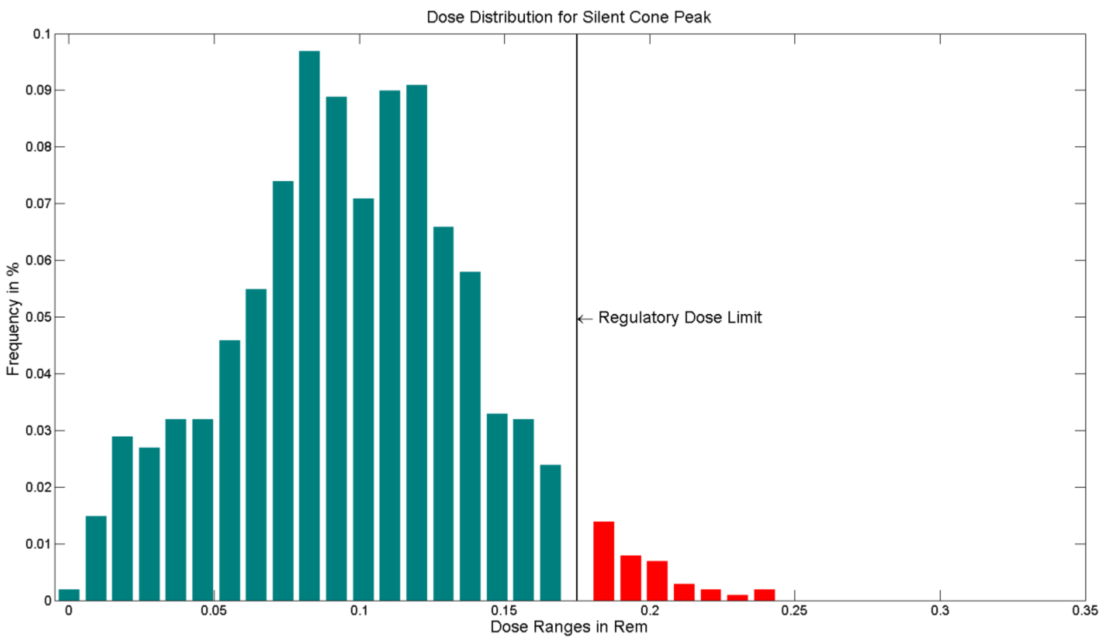

Figure 32. Matlab post processing 1000 sampled sources using normal distribution.

8. Future Upgrades

This report focused on the random sampling of release rate of cesium-137 from a distribution of possible releases. The strength of HERON in enhancing Level-3 PRA is in combining RAVEN's ability to randomly sample a variety of accident parameters with HYSPLIT's superior dispersion modeling. This table contains proposed parameters which could be sampled in future work to create a more detailed risk assessment. Additionally, the use of a shell script should be replaced with a detailed interface file written in Python to allow more fluid interaction with RAVEN.

Parameters	Description
Source	Randomly sample a distribution of possible source terms (rate of release).
Lat, Lon	Randomly pick a point of latitude and longitude to measure received dose at that point and create a geographical distribution of dose. Alternatively, allow the user to easily select one or multiple locations.
Weather	Sampling weather data from a distribution of different meteorological conditions.
Isotope	Sample the composition of the release from a distribution of concentrations of isotopes
Breathing rate	Breathing rates are not fixed in population. Randomly sampling the breathing rate from a distribution would provide more accurate received doses for the population.
Dose conversion factors	Absorbed radiation has different effects depending on where in the body it is absorbed. Random sampling of dose conversion factors from a distribution would give a better idea of the average dose.
Consequences	Introduce the ability to calculate economic consequences based on surface contamination levels.

Table 1. Proposed future variable sampling.

9. Acknowledgements

The team is grateful for the opportunity and funding provided by INL, and in particular Dr. Curtis Smith, to participate in such a rewarding experience. Additionally, the team wishes to thank INL researchers Drs. Christian Rabiti, Andrea Alfonsi, and Joshua Coglioti for their time, many helpful suggestions, and patience throughout the project. The team is also very grateful for the assistance given by Richard Eckman and his team of researchers at NOAA as well as providing the source code of HYSPLIT.

10. Conclusion

An initial proof-of-principle project coupling the NOAA Lagrangian atmospheric dispersion code HYSPLIT and the INL dynamic PRA analysis tool RAVEN has been performed to enhance Level-3 PRA. The scripts and sequencing necessary for linking the two codes is referred to as HERON. The significant advantages offered by a Lagrangian dispersion model over the traditional Gaussian plume model coupled with the ability to dynamically sample multiple parameters using RAVEN allows significant enhancement of Level-3 PRA and the conclusions that can be drawn from such assessments. While the proof-of-principle was successful, significant additional work is needed to fully realize the benefits of HERON. The necessary improvements rest in the area of parameter sampling as well as investigating effective methods of depicting the results.

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Appendix A

Statement of Work

Form 412.09

Idaho National Laboratory

ENHANCED CONSEQUENCE MODELING	Identifier: SOW-11443 Revision: 0 Effective Date: 03/12/2014 Page 3 of 4

1. INTRODUCTION

1.1 Background

This work will advance the state of the art in Level 3 Probabilistic Risk Assessment beyond current capabilities in use within the nuclear power industry. In safety analysis, a Level 3 calculation focuses on the off-site consequences resulting from the damaged core and containment. Questions such as weather conditions, population levels surrounding the plant site, and dispersion (from containment) characteristics are important in this analysis. Evaluating Level 3 analysis typically couples to a Level 1+2 model (such as in SAPHIRE). Typically, the Level 3 analysis is performed by the MACCS2 consequence analysis package – however, MACCS2 relies on technology developed decades ago, such as straight-line Gaussian plume models. The state-of-the-art in dispersion modeling has moved beyond these older models. Many of the newer models rely on Lagrangian particles representation wherein the model follows a plume as the particles move in the atmosphere, including the motion of the particles as a random walk process. These Lagrangian models calculate the dispersion by determining the statistics of the trajectories of a large number of the plume particles.

2. APPLICABLE CODES AND REFERENCES

NONE

3. SCOPE

3.1 Work to be Performed

The proposed work will investigate and develop a new module applicable to Level 1+2 PRA tools that will calculate dispersion characteristics of nuclear power plant accident releases using Lagrangian-based software. We will work with the INL NOAA Field Research Office (Kirk Clawson and Rick Eckman) to obtain the source code to the HYSPLIT software – this software will be reconstructed as a module callable by MOOSE-based applications for Level 3 PRA and will be able to interact with existing Level 1+2 tools. In addition to the HYSPLIT software, we will obtain associated meteorological data specific to each nuclear power plant site in the U.S. in order to have plant-specific information. A team member for this activity will be Dr. Pope of Idaho State University.

3.2 Place of Performance

The work will primarily be conducted at Idaho State University.

4. DELIVERABLES

NA

5. SCHEDULE AND MILESTONES

Complete year-end summary report Sept 30, 2014

6. COMPLETION CRITERIA AND FINAL ACCEPTANCE

The subcontractor will communicate directly with PI/INL Collaborators, at INL.

7. APPENDICES

NONE

8. ATTACHMENTS

NONE

Appendix B

ISU RAVEN License Agreement

License No. 14-LA-27

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By:	Linda Montgomery for	By:	Howard
Name:	Steven T. McMaster	Name:	Dr. Howard Grimes
Title:	Director, Technology Deployment	Title:	Vice President for Research
Date:	6-24-2014	Date:	7/1/14

Reviewed:
TD CM GWS 6/11/14

Appendix C

HYSPLIT Appendix

The table below defines each parameter statement of the control file. The control file reads in data sequentially as opposed to line number. This enables parameter definitions that go beyond one line. The table will use line numbers to facilitate following the example control file.

Line #	Variable Name	Format: (Structure) Description PRA Project value (Description)
1	Starting Time	Format: (year, month, day, hour, {minutes optional}) Unless specified an entry of all zeroes will start the problem at the beginning of the weather data. 14 07 29 16 50 (2014,Jul 29, 4:50 pm)
2	# of Starting Locations	Multiple starting locations can be defined, the project only required 1 location.
3	Starting Locations	Format: (lat, lon, AGL in m) Latitude, longitude and height above ground level are defined for the starting location. 43.5844 -112.9686 0 (Idaho National Laboratory)
4	Run Time	Format: (Time in hours) This is the time duration of the simulation. 3 (3 hour duration)
5	Vertical Motion Option	Format (0-5) There are 5 methods for calculating vertical motion. The default is 0 for Data. The data method uses the weather data to define the vertical velocity fields. 0 (Weather Data)
6	Top of Model Domain	Format: (Meters AGL) Defines the maximum height particles/puffs are tracked. 5000.0 (5000 meters AGL)

7	# of Input Data Grids	Format: (1- # of grids) Defines the number of meteorological files to be used. 2 (2 weather files)
8-9	Weather Data Directory and Filename	Format: \main\sub\data\ Directory Location, line 8. Format: file_name Any filename can be specified, line 9.
10	# of Different Pollutants	Format: (# of Pollutants) Each pollutants is tracked in its own particle or puff. 1 (1 Pollutant CS137)
11	Pollutant Four Character Identification	Format: (Element+Isotope) Identifies what pollutant to track CS37 (Cesium 137)
12-13	Emission Rate and Hours of Emission	Format: (Mass released per hour), line 12 The output concentration are the same units but per m^3. Format: (Duration of release in hours), line 13 The duration can be fractional hours. 52.2 (52.2 kg/hr), line 12. 1.0 (1 hour release), line 13.
14	Release Start Time	The format is the same as line 1 Start Time. 14 07 29 16 50 (2014, Jul 29, 16:50 pm)
15-18	Defines the Output Concentration Grid	These lines define the output grid of concentrations. All default values were used which means a grid centered on the emission source, with 1 degree latitude and longitude spacing.
19-20	Output Grid Directory Location and Filename	Format: (The format is the same as lines 8-9). ./ (Control File Directory), line 19. cdump (cdump file)
21	# of Vertical Concentration Levels	Format: (# of levels) Sets the number of levels for output concentration maps. 1 (1 level, ground level)
22	Height of Each Level (AGL)	Format: ((Lvl 1 in m) (Lvl 2 in m) … (Lvl n in m)) The height of each level in meters with a space between each level. 0 (Level 1, ground level)

23	Sampling Start Time	Format: (The format is the same as lines 8-9). Each concentration level can be sampled at different times during the problem duration.
24	Sampling Stop Time	Format: (The format is the same as lines 8-9). Defines the stop time for sampling.
25	Sampling Interval	Format: (type hour minute) Defines the interval and what type of sampling is to be conducted. 0 0 180 (Averaging over a 180 minute interval.)
26	# of Pollutants Depositing	Format: (Same as line 10) The following 5 lines define the deposition parameters for each pollutant. 1 (1 pollutant definition)
27	Particle Diameter, Density and Shape	Format: (Diameter (μm), Density (g/cc), and Shape.) Particle parameters are defined here. 1.0 1.873 1.0 (Properties for CS 137.)
28	Deposition Properties	To learn more about how to set these properties refer to the HYSPLIT user's guide. 4.3e-03 0.0 0.0 0.0 0.0 (4.3e-03 m/s, deposition properties)
29	Wet Removal Properties	The suggested values are used. 0.0 3.2e+05 5.0e-05
30	Radioactive Decay Half-life	Format: (Half-life in days) 11019.4 (11019.4 days, half-life Cs 137)
31	Pollutant Resuspension	The suggested value is used.

Table 2. hys control file parameter definitions.

Appendix D

Average seasonal weather data collected for regions near nuclear power plants within the United States.

Arkansas Nuclear I								
	Ave. Mean Temp.	Ave. Max Temp.	Ave. Min Temp.	Ave. Dew Point	Ave. Precipitation	Ave. Sea Level Pressure	Ave. Wind Speed	Ave. Gust Speed
January	42	52	31	33	0.22	30.17	3	19
February	42	52	33	32	0.13	30.03	4	20
March	48	59	37	34	0.12	30.07	5	19
April	60	72	48	47	0.15	29.98	4	20
May	68	79	58	58	0.13	29.97	3	19
June	78	89	67	66	0.08	29.93	2	18
July	80	93	69	66	0.04	30	2	20
August	81	92	70	68	0.1	30.01	2	20
September	77	91	64	61	0.04	29.97	2	21
October	63	74	52	53	0.11	30.05	2	20
November	47	58	36	37	0.11	30.22	3	19
December	40	49	30	32	0.18	30.16	3	18

Arkansas Nuclear II								
	Ave. Mean Temp.	Ave. Max Temp.	Ave. Min Temp.	Ave. Dew Point	Ave. Precipitation	Ave. Sea Level Pressure	Ave. Wind Speed	Ave. Gust Speed
January	42	52	31	33	0.22	30.17	3	19
February	42	52	33	32	0.13	30.03	4	20
March	48	59	37	34	0.12	30.07	5	19
April	60	72	48	47	0.15	29.98	4	20
May	68	79	58	58	0.13	29.97	3	19
June	78	89	67	66	0.08	29.93	2	18
July	80	93	69	66	0.04	30	2	20
August	81	92	70	68	0.1	30.01	2	20
September	77	91	64	61	0.04	29.97	2	21
October	63	74	52	53	0.11	30.05	2	20
November	47	58	36	37	0.11	30.22	3	19
December	40	49	30	32	0.18	30.16	3	18

Beaver Valley-I								
	Ave. Mean Temp.	**Ave. Max Temp.**	**Ave. Min Temp.**	**Ave. Dew Point**	**Ave. Precipitation**	**Ave. Sea Level Pressure**	**Ave. Wind Speed**	**Ave. Gust Speed**
January	32 °F	37 °F	27 °F	23 °F	0.00 in	30.12 in	8 mph	20 mph
February	29 °F	34 °F	23 °F	20 °F	0.00 in	29.97 in	8 mph	20 mph
March	35 °F	40 °F	29 °F	23 °F	0.00 in	29.97 in	7 mph	19 mph
April	51 °F	61 °F	42 °F	33 °F	0.00 in	30.06 in	8 mph	21 mph
May	63 °F	73 °F	53 °F	45 °F	0.00 in	30.05 in	7 mph	20 mph
June	69 °F	77 °F	61 °F	56 °F	0.00 in	29.96 in	5 mph	19 mph
July	72 °F	80 °F	65 °F	62 °F	0.00 in	30.08 in	4 mph	20 mph
August	70 °F	79 °F	62 °F	60 °F	0.00 in	30.07 in	4 mph	17 mph
September	64 °F	72 °F	54 °F	54 °F	0.00 in	30.07 in	4 mph	17 mph
October	55 °F	63 °F	47 °F	46 °F	0.00 in	30.06 in	5 mph	19 mph
November	39 °F	45 °F	32 °F	29 °F	0.00 in	30.16 in	8 mph	20 mph
December	34 °F	38 °F	29 °F	27 °F	0.00 in	30.05 in	7 mph	19 mph

Beaver Valley-2								
	Ave. Mean Temp.	**Ave. Max Temp.**	**Ave. Min Temp.**	**Ave. Dew Point**	**Ave. Precipitation**	**Ave. Sea Level Pressure**	**Ave. Wind Speed**	**Ave. Gust Speed**
January	32 °F	37 °F	27 °F	23 °F	0.00 in	30.12 in	8 mph	20 mph
February	29 °F	34 °F	23 °F	20 °F	0.00 in	29.97 in	8 mph	20 mph
March	35 °F	40 °F	29 °F	23 °F	0.00 in	29.97 in	7 mph	19 mph
April	51 °F	61 °F	42 °F	33 °F	0.00 in	30.06 in	8 mph	21 mph
May	63 °F	73 °F	53 °F	45 °F	0.00 in	30.05 in	7 mph	20 mph
June	69 °F	77 °F	61 °F	56 °F	0.00 in	29.96 in	5 mph	19 mph
July	72 °F	80 °F	65 °F	62 °F	0.00 in	30.08 in	4 mph	20 mph
August	70 °F	79 °F	62 °F	60 °F	0.00 in	30.07 in	4 mph	17 mph
September	64 °F	72 °F	54 °F	54 °F	0.00 in	30.07 in	4 mph	17 mph
October	55 °F	63 °F	47 °F	46 °F	0.00 in	30.06 in	5 mph	19 mph
November	39 °F	45 °F	32 °F	29 °F	0.00 in	30.16 in	8 mph	20 mph
December	34 °F	38 °F	29 °F	27 °F	0.00 in	30.05 in	7 mph	19 mph

Big Rock Point								
	Ave. Mean Temp. ('F)	**Ave. Max Temp. ('F)**	**Ave. Min Temp. ('F)**	**Ave. Dew Point ('F)**	**Ave. Precipitation (inch)**	**Ave. Sea Level Pressure (inch)**	**Ave. Wind Speed (mph)**	**Ave. Gust Speed (mph)**
January	26	31	21	20	0.00	30.00	11	22
February	22	28	17	18	0.00	29.96	10	22
March	27	33	22	23	0.00	30.04	9	20
April	39	46	31	31	0.00	30.02	10	21
May	53	63	43	44	0.00	30.03	7	20
June	61	70	52	53	0.00	29.97	5	19
July	68	77	59	60	0.00	30.04	6	19
August	66	75	58	59	0.00	30.05	6	19
September	59	67	51	53	0.00	30.05	8	19
October	50	57	43	44	0.00	29.98	9	21
November	36	42	31	29	0.00	30.08	13	24
December	21	26	17	16	0.00	30.05	12	22

Braidwood 1

	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	27	36	18	21	0.06	30.11	10	23
February	27	34	20	23	0.04	29.99	10	22
March	32	40	25	26	0.03	30.05	9	21
April	48	59	38	38	0.18	29.99	10	23
May	64	75	52	51	0.14	29.96	7	20
June	70	81	60	59	0.11	29.92	5	20
July	73	83	63	63	0.02	30.04	4	20
August	71	82	60	62	0.05	30.05	3	19
September	66	79	54	56	0.03	30.02	4	18
October	53	65	42	42	0.10	30.00	6	19
November	38	46	29	28	0.05	30.16	10	22
December	22	31	14	17	0.03	30.10	8	21

Braidwood-2

	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	27	36	18	21	0.06	30.11	10	23
February	27	34	20	23	0.04	29.99	10	22
March	32	40	25	26	0.03	30.05	9	21
April	48	59	38	38	0.18	29.99	10	23
May	64	75	52	51	0.14	29.96	7	20
June	70	81	60	59	0.11	29.92	5	20
July	73	83	63	63	0.02	30.04	4	20
August	71	82	60	62	0.05	30.05	3	19
September	66	79	54	56	0.03	30.02	4	18
October	53	65	42	42	0.10	30.00	6	19
November	38	46	29	28	0.05	30.16	10	22
December	22	31	14	17	0.03	30.10	8	21

Browns Ferry-1

	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	45	52	37	37	0.23	30.21	7	24
February	44	52	34	34	0.10	30.06	7	25
March	46	56	36	35	0.17	30.08	8	23
April	59	70	49	49	0.16	30.06	7	20
May	66	77	56	57	0.16	30.04	5	20
June	78	89	67	67	0.11	29.96	5	23
July	77	87	69	69	0.32	30.04	4	25
August	76	87	67	69	0.05	30.06	3	22
September	73	84	61	63	0.14	30.02	3	22
October	62	74	51	53	0.05	30.09	4	21
November	47	58	35	35	0.10	30.25	6	23
December	44	54	34	36	0.18	30.18	7	21

Browns Ferry-2								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	45	52	37	37	0.23	30.21	7	24
February	44	52	34	34	0.10	30.06	7	25
March	46	56	36	35	0.17	30.08	8	23
April	59	70	49	49	0.16	30.06	7	20
May	66	77	56	57	0.16	30.04	5	20
June	78	89	67	67	0.11	29.96	5	23
July	77	87	69	69	0.32	30.04	4	25
August	76	87	67	69	0.05	30.06	3	22
September	73	84	61	63	0.14	30.02	3	22
October	62	74	51	53	0.05	30.09	4	21
November	47	58	35	35	0.10	30.25	6	23
December	44	54	34	36	0.18	30.18	7	21

Browns Ferry-3								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	45	52	37	37	0.23	30.21	7	24
February	44	52	34	34	0.10	30.06	7	25
March	46	56	36	35	0.17	30.08	8	23
April	59	70	49	49	0.16	30.06	7	20
May	66	77	56	57	0.16	30.04	5	20
June	78	89	67	67	0.11	29.96	5	23
July	77	87	69	69	0.32	30.04	4	25
August	76	87	67	69	0.05	30.06	3	22
September	73	84	61	63	0.14	30.02	3	22
October	62	74	51	53	0.05	30.09	4	21
November	47	58	35	35	0.10	30.25	6	23
December	44	54	34	36	0.18	30.18	7	21

Brunswick-1								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	48	57	40	41	0.04	30.21	6	19
February	45	54	37	37	0.13	30.05	7	19
March	46	56	37	33	0.09	30.01	7	20
April	59	67	51	52	0.22	30.12	6	19
May	67	75	59	59	0.05	30.09	6	18
June	78	83	72	71	0.20	30.00	8	19
July	80	85	74	73	0.16	30.09	6	18
August	78	85	71	71	0.12	30.05	6	18
September	74	82	66	65	0.02	30.02	5	18
October	65	73	56	57	0.03	30.06	5	18
November	54	64	43	45	0.08	30.21	7	19
December	51	60	41	45	0.04	30.18	5	19

Brunswick-2								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	48	57	40	41	0.04	30.21	6	19
February	45	54	37	37	0.13	30.05	7	19
March	46	56	37	33	0.09	30.01	7	20
April	59	67	51	52	0.22	30.12	6	19
May	67	75	59	59	0.05	30.09	6	18
June	78	83	72	71	0.20	30.00	8	19
July	80	85	74	73	0.16	30.09	6	18
August	78	85	71	71	0.12	30.05	6	18
September	74	82	66	65	0.02	30.02	5	18
October	65	73	56	57	0.03	30.06	5	18
November	54	64	43	45	0.08	30.21	7	19
December	51	60	41	45	0.04	30.18	5	19

Byron-1								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	25	34	15	17	0.12	30.13	10	24
February	24	31	16	19	0.14	30.01	10	24
March	30	37	22	22	0.12	30.09	9	24
April	47	57	37	35	0.33	30.00	11	24
May	62	73	51	49	0.13	29.97	9	23
June	70	80	59	58	0.29	29.93	7	24
July	73	83	63	62	0.07	30.04	6	20
August	72	83	61	61	0.11	30.06	6	21
September	67	78	55	55	0.06	30.03	7	21
October	52	62	41	43	0.13	30.02	7	21
November	36	44	26	27	0.08	30.18	10	24
December	20	28	10	15	0.07	30.12	8	23

Byron-2								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	25	34	15	17	0.12	30.13	10	24
February	24	31	16	19	0.14	30.01	10	24
March	30	37	22	22	0.12	30.09	9	24
April	47	57	37	35	0.33	30.00	11	24
May	62	73	51	49	0.13	29.97	9	23
June	70	80	59	58	0.29	29.93	7	24
July	73	83	63	62	0.07	30.04	6	20
August	72	83	61	61	0.11	30.06	6	21
September	67	78	55	55	0.06	30.03	7	21
October	52	62	41	43	0.13	30.02	7	21
November	36	44	26	27	0.08	30.18	10	24
December	20	28	10	15	0.07	30.12	8	23

Callaway-1

	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	34	44	24	23	0.08	30.18	10	24
February	34	43	25	24	0.14	30.03	11	25
March	39	48	30	28	0.13	30.08	11	25
April	54	64	43	40	0.26	29.98	10	24
May	64	74	54	54	0.35	29.96	10	24
June	74	83	64	63	0.08	29.93	9	23
July	75	85	65	64	0.09	30.03	7	22
August	76	86	65	65	0.06	30.04	6	23
September	71	83	59	59	0.09	30.00	7	20
October	57	68	45	45	0.10	30.04	9	22
November	42	52	32	30	0.06	30.22	11	25
December	30	40	20	22	0.06	30.15	9	22

Calvert-Cliffs-1

	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	39	47	32	29	0.10	30.17	7	22
February	38	44	31	27	0.06	30.02	9	25
March	42	50	34	28	0.09	29.97	10	24
April	56	65	48	43	0.15	30.12	8	22
May	65	75	57	53	0.04	30.07	8	21
June	75	84	67	64	0.22	29.94	7	21
July	79	87	72	69	0.13	30.05	6	19
August	74	81	66	65	0.13	30.04	6	21
September	68	78	58	57	0.05	30.03	7	22
October	60	68	52	51	0.18	30.06	7	21
November	47	55	38	33	0.08	30.22	10	25
December	41	49	32	32	0.16	30.14	8	24

Calvert Cliffs-2

	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	39	47	32	29	0.10	30.17	7	22
February	38	44	31	27	0.06	30.02	9	25
March	42	50	34	28	0.09	29.97	10	24
April	56	65	48	43	0.15	30.12	8	22
May	65	75	57	53	0.04	30.07	8	21
June	75	84	67	64	0.22	29.94	7	21
July	79	87	72	69	0.13	30.05	6	19
August	74	81	66	65	0.13	30.04	6	21
September	68	78	58	57	0.05	30.03	7	22
October	60	68	52	51	0.18	30.06	7	21
November	47	55	38	33	0.08	30.22	10	25
December	41	49	32	32	0.16	30.14	8	24

Catawba-1								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	46	55	35	37	0.11	30.20	4	22
February	43	53	32	31	0.11	30.05	6	21
March	45	57	33	29	0.09	30.04	5	20
April	61	72	49	48	0.14	30.10	5	19
May	66	77	56	56	0.10	30.07	5	19
June	76	86	67	68	0.22	29.98	5	20
July	78	86	71	72	0.17	30.07	4	21
August	76	84	67	69	0.13	30.06	4	21
September	71	83	61	62	0.04	30.03	3	19
October	63	75	51	54	0.02	30.08	4	19
November	48	59	36	36	0.11	30.24	5	20
December	46	56	36	37	0.20	30.17	5	20

Catawba-2								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	46	55	35	37	0.11	30.20	4	22
February	43	53	32	31	0.11	30.05	6	21
March	45	57	33	29	0.09	30.04	5	20
April	61	72	49	48	0.14	30.10	5	19
May	66	77	56	56	0.10	30.07	5	19
June	76	86	67	68	0.22	29.98	5	20
July	78	86	71	72	0.17	30.07	4	21
August	76	84	67	69	0.13	30.06	4	21
September	71	83	61	62	0.04	30.03	3	19
October	63	75	51	54	0.02	30.08	4	19
November	48	59	36	36	0.11	30.24	5	20
December	46	56	36	37	0.20	30.17	5	20

Clinton-1								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	30	39	21	23	0.09	30.15	7	20
February	32	39	24	25	0.07	30.01	7	20
March	36	44	28	28	0.05	30.06	7	19
April	51	62	41	40	0.19	29.99	7	20
May	65	75	55	55	0.00	29.96	6	20
June	73	83	64	61	0.00	29.91	4	19
July	74	84	64	64	0.00	30.02	2	18
August	73	85	62	64	0.04	30.03	1	19
September	69	82	56	57	0.00	30.00	3	18
October	55	67	44	45	0.00	30.02	4	18
November	39	49	30	31	0.02	30.21	7	19
December	28	36	19	22	0.01	30.14	6	18

Columbia (WNP-2)								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	33	38	27	27	0.01	30.30	4	27
February	40	52	27	30	0.00	30.17	6	25
March	47	60	33	33	0.01	30.11	7	27
April	52	66	38	34	0.02	30.07	8	27
May	62	77	46	42	0.02	30.00	6	24
June	68	83	54	49	0.04	29.94	6	21
July	77	95	58	49	0.00	29.88	4	20
August	75	91	59	54	0.02	29.89	5	26
September	67	80	53	52	0.04	29.84	6	26
October	49	64	35	38	0.00	30.13	4	29
November	38	48	28	30	0.02	30.19	6	29
December	28	37	18	20	0.01	30.30	5	28

Comanche Peak-1								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	48	60	37	37	0.12	30.17	6	20
February	51	64	39	36	0.03	30.03	8	21
March	57	69	44	39	0.06	30.07	9	21
April	64	75	52	50	0.04	29.96	9	21
May	73	85	62	59	0.07	29.96	9	21
June	84	95	72	63	0.05	29.94	7	20
July	84	95	74	64	0.09	30.00	6	18
August	87	99	76	64	0.02	30.00	5	17
September	81	92	70	62	0.14	29.96	4	19
October	67	78	57	56	0.11	30.04	6	20
November	52	63	42	41	0.04	30.22	6	19
December	43	55	31	33	0.06	30.17	5	19

Comanche Peak-2								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	48	60	37	37	0.12	30.17	6	20
February	51	64	39	36	0.03	30.03	8	21
March	57	69	44	39	0.06	30.07	9	21
April	64	75	52	50	0.04	29.96	9	21
May	73	85	62	59	0.07	29.96	9	21
June	84	95	72	63	0.05	29.94	7	20
July	84	95	74	64	0.09	30.00	6	18
August	87	99	76	64	0.02	30.00	5	17
September	81	92	70	62	0.14	29.96	4	19
October	67	78	57	56	0.11	30.04	6	20
November	52	63	42	41	0.04	30.22	6	19
December	43	55	31	33	0.06	30.17	5	19

Cooper								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	28	38	18	19	0.01	30.12	8	21
February	30	39	21	22	0.00	30.01	8	22
March	36	45	27	25	0.03	30.07	9	21
April	47	59	36	35	0.14	29.95	11	23
May	62	72	52	51	0.22	29.94	11	21
June	72	81	63	61	0.11	29.91	9	22
July	74	84	65	63	0.04	30.03	6	18
August	75	85	66	66	0.03	30.04	6	19
September	70	81	59	58	0.08	29.98	8	21
October	53	64	42	41	0.09	29.99	9	21
November	38	49	28	27	0.03	30.15	10	22
December	24	33	14	15	0.00	30.11	10	22

Crystal River-3								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	62	74	51	55	0.01	30.18	4	18
February	60	72	48	50	0.06	30.07	4	18
March	56	69	43	43	0.01	30.09	4	19
April	71	83	59	60	0.03	30.05	4	18
May	72	83	60	61	0.05	30.04	4	18
June	79	87	71	71	0.30	30.00	3	19
July	80	88	71	72	0.35	30.06	2	18
August	81	89	72	72	0.31	30.03	2	18
September	79	88	70	70	0.19	29.97	3	18
October	73	83	62	62	0.02	30.03	2	17
November	65	75	56	57	0.16	30.12	5	19
December	63	74	52	54	0.07	30.15	3	17

Diablo Canyon-1								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	51	64	38	40	0.03	30.16	3	31
February	51	64	38	40	0.01	30.13	4	21
March	57	69	46	46	0.02	30.07	5	31
April	58	71	47	47	0.00	30.01	6	26
May	62	76	49	49	0.00	29.99	7	28
June	65	78	54	52	0.00	29.91	6	28
July	67	78	55	55	0.00	29.94	6	34
August	66	78	55	54	0.00	29.95	6	35
September	67	81	55	52	0.00	29.88	6	35
October	62	75	50	45	0.00	29.98	4	37
November	58	72	45	43	0.01	30.03	4	23
December	54	70	38	31	0.01	30.12	3	22

Diablo Canyon-2

	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	51	64	38	40	0.03	30.16	3	31
February	51	64	38	40	0.01	30.13	4	21
March	57	69	46	46	0.02	30.07	5	31
April	58	71	47	47	0.00	30.01	6	26
May	62	76	49	49	0.00	29.99	7	28
June	65	78	54	52	0.00	29.91	6	28
July	67	78	55	55	0.00	29.94	6	34
August	66	78	55	54	0.00	29.95	6	35
September	67	81	55	52	0.00	29.88	6	35
October	62	75	50	45	0.00	29.98	4	37
November	58	72	45	43	0.01	30.03	4	23
December	54	70	38	31	0.01	30.12	3	22

Donald Cook-1

	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	29	36	22	22	0.08	30.09	11	23
February	27	33	21	21	0.07	29.98	10	23
March	32	38	26	24	0.04	30.04	8	20
April	45	56	36	35	0.21	30.01	9	22
May	61	71	50	49	0.08	29.98	6	21
June	66	76	57	58	0.08	29.92	5	20
July	70	80	62	63	0.04	30.03	5	21
August	68	79	58	61	0.07	30.05	4	21
September	63	74	52	55	0.05	30.03	5	18
October	53	62	44	46	0.22	30.01	7	22
November	38	44	33	31	0.12	30.16	10	22
December	26	32	21	21	0.05	30.08	10	22

Donald Cook-2

	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	29	36	22	22	0.08	30.09	11	23
February	27	33	21	21	0.07	29.98	10	23
March	32	38	26	24	0.04	30.04	8	20
April	45	56	36	35	0.21	30.01	9	22
May	61	71	50	49	0.08	29.98	6	21
June	66	76	57	58	0.08	29.92	5	20
July	70	80	62	63	0.04	30.03	5	21
August	68	79	58	61	0.07	30.05	4	21
September	63	74	52	55	0.05	30.03	5	18
October	53	62	44	46	0.22	30.01	7	22
November	38	44	33	31	0.12	30.16	10	22
December	26	32	21	21	0.05	30.08	10	22

Dresden-1								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	27	36	18	21	0.06	30.61	10	23
February	27	34	20	23	0.04	29.99	10	22
March	32	40	25	26	0.03	30.05	9	21
April	48	59	38	38	0.18	29.99	10	23
May	64	75	52	51	0.14	29.96	7	20
June	60	70	81	59	0.11	29.92	5	20
July	73	83	63	63	0.02	30.04	4	20
August	71	82	60	62	0.05	30.05	3	19
September	66	79	54	56	0.03	30.02	4	18
October	53	65	42	42	0.10	30.00	6	19
November	38	46	29	28	0.05	30.16	10	22
December	22	31	14	17	0.03	30.10	8	21

Dresden-2								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	27	36	18	21	0.06	30.61	10	23
February	27	34	20	23	0.04	29.99	10	22
March	32	40	25	26	0.03	30.05	9	21
April	48	59	38	38	0.18	29.99	10	23
May	64	75	52	51	0.14	29.96	7	20
June	60	70	81	59	0.11	29.92	5	20
July	73	83	63	63	0.02	30.04	4	20
August	71	82	60	62	0.05	30.05	3	19
September	66	79	54	56	0.03	30.02	4	18
October	53	65	42	42	0.10	30.00	6	19
November	38	46	29	28	0.05	30.16	10	22
December	22	31	14	17	0.03	30.10	8	21

Dresden-3								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	27	36	18	21	0.06	30.61	10	23
February	27	34	20	23	0.04	29.99	10	22
March	32	40	25	26	0.03	30.05	9	21
April	48	59	38	38	0.18	29.99	10	23
May	64	75	52	51	0.14	29.96	7	20
June	60	70	81	59	0.11	29.92	5	20
July	73	83	63	63	0.02	30.04	4	20
August	71	82	60	62	0.05	30.05	3	19
September	66	79	54	56	0.03	30.02	4	18
October	53	65	42	42	0.10	30.00	6	19
November	38	46	29	28	0.05	30.16	10	22
December	22	31	14	17	0.03	30.10	8	21

Duane Arnold-1								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	23	33	13	17	0.05	30.12	12	27
February	25	33	17	20	0.06	30.00	12	28
March	29	37	21	24	0.09	30.08	11	27
April	47	57	36	36	0.39	29.96	12	24
May	61	71	51	51	0.28	29.93	11	24
June	70	79	61	60	0.24	29.90	8	25
July	72	82	62	62	0.10	30.02	7	21
August	73	84	61	62	0.00	30.03	6	19
September	67	80	54	55	0.08	29.99	8	22
October	51	62	40	40	0.12	29.98	9	22
November	34	44	24	26	0.09	30.16	11	25
December	17	26	8	13	0.03	30.12	10	26

Elk River								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	13	22	4	7	0.01	30.02	7	20
February	14	24	4	9	0.01	29.99	6	19
March	22	31	12	14	0.05	30.08	6	19
April	36	45	28	26	0.04	29.96	8	19
May	54	65	42	41	0.07	29.98	7	20
June	64	75	54	55	0.10	29.92	6	20
July	70	80	60	59	0.05	30.00	5	19
August	69	83	56	57	0.01	30.01	4	18
September	64	76	51	54	0.08	29.96	6	19
October	46	55	38	39	0.11	29.94	6	19
November	30	40	20	22	0.02	30.07	7	20
December	7	17	-2	3	0.02	30.07	6	19

Enrico Fermi-1								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	29	37	22	24	0.00	30.08	9	21
February	28	34	21	22	0.00	29.97	9	20
March	35	41	28	26	0.00	29.99	9	20
April	46	56	37	36	0.00	30.02	8	21
May	63	74	52	50	0.00	30.00	7	20
June	69	78	61	60	0.00	29.92	5	18
July	73	81	65	66	0.00	30.03	4	19
August	71	81	61	64	0.00	30.04	3	17
September	65	75	54	58	0.00	30.03	4	18
October	54	64	44	47	0.00	30.01	6	19
November	38	45	30	29	0.00	30.15	9	21
December	27	33	21	22	0.00	30.06	8	20

Enrico Fermi-2

	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	29	37	22	24	0.00	30.08	9	21
February	28	34	21	22	0.00	29.97	9	20
March	35	41	28	26	0.00	29.99	9	20
April	46	56	37	36	0.00	30.02	8	21
May	63	74	52	50	0.00	30.00	7	20
June	69	78	61	60	0.00	29.92	5	18
July	73	81	65	66	0.00	30.03	4	19
August	71	81	61	64	0.00	30.04	3	17
September	65	75	54	58	0.00	30.03	4	18
October	54	64	44	47	0.00	30.01	6	19
November	38	45	30	29	0.00	30.15	9	21
December	27	33	21	22	0.00	30.06	8	20

Farley-1

	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	57	69	46	50	0.00	30.20	4	18
February	52	63	41	44	0.00	30.07	2	18
March	54	67	42	42	0.00	30.09	3	18
April	64	77	51	57	0.00	30.07	2	18
May	69	83	56	60	0.00	30.06	2	17
June	78	90	66	72	0.00	29.99	2	19
July	69	69	69	70	0.00	30.05	2	20
August	73	86	61	67	0.00	30.05	1	20
September	75	84	66	70	0.00	30.00	2	16
October	66	77	55	60	0.00	30.07	1	18
November	55	66	44	48	0.00	30.19	4	18
December	53	64	43	49	0.00	30.17	3	18

Farley-2

	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave Humidity	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	57	69	46	50		30.20	4	18
February	52	63	41	44		30.07	2	18
March	54	67	42	42		30.09	3	18
April	64	77	51	57		30.07	2	18
May	69	83	56	60		30.06	2	17
June	78	90	66	72		29.99	2	19
July	69	69	69	70		30.05	2	20
August	73	86	61	67		30.05	1	20
September	75	84	66	70		30.00	2	16
October	66	77	55	60		30.07	1	18
November	55	66	44	48		30.19	4	18
December	53	64	43	49		30.17	3	18

Fitzpatrick								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	26	34	18	19	0.08	30.08	8	23
February	26	33	19	18	0.10	29.98	8	23
March	32	38	26	23	0.05	29.95	8	22
April	45	88	36	32	0.09	30.09	9	24
May	59	71	48	46	0.12	30.03	5	22
June	65	73	56	56	0.24	29.91	5	20
July	72	82	63	64	0.11	30.02	4	20
August	68	78	58	59	0.08	30.01	4	20
September	60	70	49	52	0.12	30.02	4	21
October	52	61	44	44	0.15	30.03	5	22
November	37	44	29	27	0.14	30.13	9	24
December	27	33	21	21	0.07	30.06	7	21

Fort-Calhoun-1								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	25	34	17	18	0.01	30.09	10	22
February	29	38	20	22	0.00	29.99	11	23
March	34	42	26	25	0.02	30.06	11	22
April	46	57	35	34	0.11	29.94	12	23
May	60	70	51	48	0.17	29.93	11	23
June	70	79	62	59	0.11	29.91	9	21
July	74	84	65	61	0.03	30.02	7	19
August	74	84	65	64	0.07	30.04	7	19
September	70	80	59	57	0.06	29.96	9	20
October	52	62	41	39	0.07	29.97	9	21
November	37	47	27	25	0.04	30.13	11	23
December	22	31	13	12	0.00	30.09	10	23

Fort St. Vrain								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	26	42	10	12	0.00	30.03	4	25
February	27	42	12	14	0.00	29.96	6	25
March	37	51	22	22	0.01	30.02	7	26
April	42	55	28	25	0.01	29.96	8	26
May	57	72	42	37	0.03	30.01	8	23
June	70	87	52	44	0.02	30.02	7	22
July	72	88	57	53	0.02	30.11	7	22
August	72	89	56	52	0.08	30.13	5	22
September	66	79	53	49	0.09	30.03	6	21
October	46	59	33	32	0.02	30.04	6	23
November	37	57	21	21	0.00	30.09	6	27
December	23	38	9	11	0.00	30.02	5	26

H. B. Robinson-2								
	Ave. Mean Temp. ('F)	**Ave. Max Temp. ('F)**	**Ave. Min Temp. ('F)**	**Ave. Dew Point ('F)**	**Ave. Precipitation (inch)**	**Ave. Sea Level Pressure (inch)**	**Ave. Wind Speed (mph)**	**Ave. Gust Speed (mph)**
January	50	60	40	40	0.00	30.20	3	18
February	47	57	36	35	0.00	30.05	4	18
March	50	61	39	31	0.00	30.02	4	19
April	64	75	54	50	0.00	30.12	4	19
May	70	80	59	56	0.00	30.09	3	18
June	78	88	69	68	0.00	30.00	2	18
July	80	88	72	73	0.00	30.09	1	18
August	78	87	69	69	0.00	30.07	2	17
September	74	85	64	61	0.00	30.04	3	17
October	65	75	55	55	0.00	30.08	3	17
November	52	63	41	38	0.00	30.23	5	18
December	51	61	40	42	0.00	30.18	3	18

Haddam Neck								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	32	38	26	22	0.22	30.09	7	22
February	32	37	26	21	0.37	29.95	7	21
March	38	44	32	25	0.59	29.89	9	20
April	48	57	39	34	0.08	30.13	7	20
May	58	68	49	49	0.17	30.07	6	19
June	68	77	60	60	0.90	29.94	6	18
July	76	83	69	69	0.24	30.04	5	18
August	70	77	62	61	0.14	30.03	5	17
September	63	72	53	54	0.14	30.03	5	18
October	56	64	47	46	0.14	30.07	5	19
November	42	50	35	29	0.24	30.14	8	21
December	34	40	28	27	0.93	30.08	6	19

Hallam								
	Ave. Mean Temp. ('F)	**Ave. Max Temp. ('F)**	**Ave. Min Temp. ('F)**	**Ave. Dew Point ('F)**	**Ave. Precipitation (inch)**	**Ave. Sea Level Pressure (inch)**	**Ave. Wind Speed (mph)**	**Ave. Gust Speed (mph)**
January	28	38	18	18	0.01	30.12	8	21
February	32	41	22	21	0.01	30.01	10	21
March	37	48	26	24	0.03	30.07	10	23
April	48	59	36	33	0.10	29.95	10	23
May	62	72	51	50	0.19	29.94	10	21
June	73	84	63	61	0.04	29.91	10	22
July	77	88	66	63	0.08	30.02	7	19
August	76	85	67	68	0.13	30.04	7	18
September	71	82	59	59	0.10	29.97	8	21
October	52	64	40	41	0.15	29.99	8	21
November	38	50	25	26	0.06	30.15	9	22
December	24	35	12	15	0.00	30.11	9	22

Hatch-1								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	57	69	45	47	0.02	30.20	5	20
February	54	65	43	42	0.34	30.06	5	20
March	53	65	41	38	0.08	30.07	7	21
April	66	78	52	55	0.11	30.07	5	19
May	71	82	59	58	0.11	30.06	5	19
June	80	89	71	70	0.26	29.99	5	21
July	81	89	72	72	0.24	30.05	4	21
August	82	91	72	73	0.34	30.04	3	20
September	78	87	68	69	0.08	30.00	3	21
October	68	80	56	59	0.02	30.06	3	19
November	58	69	47	49	0.15	30.18	5	19
December	57	68	45	47	0.11	30.16	5	21

Hatch-2								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	57	69	45	47	0.02	30.20	5	20
February	54	65	43	42	0.34	30.06	5	20
March	53	65	41	38	0.08	30.07	7	21
April	66	78	52	55	0.11	30.07	5	19
May	71	82	59	58	0.11	30.06	5	19
June	80	89	71	70	0.26	29.99	5	21
July	81	89	72	72	0.24	30.05	4	21
August	82	91	72	73	0.34	30.04	3	20
September	78	87	68	69	0.08	30.00	3	21
October	68	80	56	59	0.02	30.06	3	19
November	58	69	47	49	0.15	30.18	5	19
December	57	68	45	47	0.11	30.16	5	21

Hope Creek-1								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	36	44	28	26	0.13	30.17	7	24
February	35	42	27	25	0.11	30.02	10	25
March	41	49	32	26	0.09	29.96	11	25
April	54	64	44	39	0.11	30.14	9	24
May	64	74	53	52	0.07	30.08	8	21
June	73	82	64	63	0.49	29.93	7	23
July	80	87	72	69	0.15	30.04	7	21
August	74	82	65	64	0.21	30.04	6	22
September	66	77	55	55	0.07	30.04	6	21
October	59	69	49	49	0.07	30.08	8	23
November	44	54	34	30	0.10	30.21	9	25
December	38	46	29	29	0.18	30.13	7	23

Humbolt Bat								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	44	51	37	39	0.09	30.25	3	-
February	45	52	38	40	0.07	30.24	5	-
March	48	54	42	43	0.12	30.16	6	-
April	51	56	45	44	0.05	30.17	7	-
May	55	61	48	48	0.03	30.11	6	-
June	58	63	52	51	0.01	30.04	5	-
July	57	61	52	51	0.00	30.00	6	-
August	60	66	54	54	0.00	30.01	5	-
September	61	67	54	54	0.09	29.97	5	-
October	51	58	44	43	0.00	30.08	4	-
November	50	58	41	42	0.05	30.13	4	-
December	43	51	34	36	0.02	30.25	3	-

Indian Point-1								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	32	38	25	21	0.08	30.11	8	23
February	31	37	25	20	0.06	29.98	10	25
March	38	44	31	24	0.05	29.92	11	23
April	49	58	40	33	0.04	30.12	8	22
May	59	69	50	48	0.16	30.06	6	20
June	69	78	61	59	0.27	29.91	6	20
July	77	84	70	67	0.19	30.02	5	18
August	70	79	63	60	0.10	30.01	5	19
September	63	73	54	53	0.03	30.02	5	21
October	56	65	48	46	0.00	30.06	5	20
November	41	49	33	28	0.12	30.16	8	24
December	34	41	28	25	0.11	30.10	7	22

Indian Point-2								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	32	38	25	21	0.08	30.11	8	23
February	31	37	25	20	0.06	29.98	10	25
March	38	44	31	24	0.05	29.92	11	23
April	49	58	40	33	0.04	30.12	8	22
May	59	69	50	48	0.16	30.06	6	20
June	69	78	61	59	0.27	29.91	6	20
July	77	84	70	67	0.19	30.02	5	18
August	70	79	63	60	0.10	30.01	5	19
September	63	73	54	53	0.03	30.02	5	21
October	56	65	48	46	0.00	30.06	5	20
November	41	49	33	28	0.12	30.16	8	24
December	34	41	28	25	0.11	30.10	7	22

Indian Point-3								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	32	38	25	21	0.08	30.11	8	23
February	31	37	25	20	0.06	29.98	10	25
March	38	44	31	24	0.05	29.92	11	23
April	49	58	40	33	0.04	30.12	8	22
May	59	69	50	48	0.16	30.06	6	20
June	69	78	61	59	0.27	29.91	6	20
July	77	84	70	67	0.19	30.02	5	18
August	70	79	63	60	0.10	30.01	5	19
September	63	73	54	53	0.03	30.02	5	21
October	56	65	48	46	0.00	30.06	5	20
November	41	49	33	28	0.12	30.16	8	24
December	34	41	28	25	0.11	30.10	7	22

LaSalle-1								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	27	36	18	21	0.06	30.11	10	23
February	27	34	20	23	0.04	29.99	10	22
March	32	40	25	26	0.03	30.05	9	21
April	48	59	38	38	0.18	30.50	10	23
May	64	75	52	51	0.14	29.96	7	20
June	70	81	60	59	0.11	29.92	5	20
July	73	83	63	63	0.02	30.04	4	20
August	71	82	60	62	0.05	30.05	3	19
September	66	79	54	56	0.03	30.02	4	18
October	53	65	42	42	0.10	30.00	6	19
November	38	46	29	28	0.05	30.16	10	22
December	22	31	14	17	0.03	30.10	8	21

LaSalle-2								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	27	36	18	21	0.06	30.11	10	23
February	27	34	20	23	0.04	29.99	10	22
March	32	40	25	26	0.03	30.05	9	21
April	48	59	38	38	0.18	30.50	10	23
May	64	75	52	51	0.14	29.96	7	20
June	70	81	60	59	0.11	29.92	5	20
July	73	83	63	63	0.02	30.04	4	20
August	71	82	60	62	0.05	30.05	3	19
September	66	79	54	56	0.03	30.02	4	18
October	53	65	42	42	0.10	30.00	6	19
November	38	46	29	28	0.05	30.16	10	22
December	22	31	14	17	0.03	30.10	8	21

Limerick-1								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	33	41	26	25	0.13	30.14	4	20
February	32	39	25	23	0.07	30.00	5	21
March	39	47	31	26	0.08	29.95	7	20
April	50	63	39	37	0.12	30.13	5	20
May	61	72	51	50	0.10	30.08	3	18
June	71	81	62	62	0.25	29.93	3	20
July	77	85	69	68	0.15	30.05	3	18
August	71	79	62	63	0.17	30.04	2	18
September	64	75	52	54	0.03	30.05	2	19
October	56	66	46	47	0.09	30.08	3	19
November	41	50	32	29	0.08	30.19	5	22
December	34	42	26	28	0.15	30.12	4	20

Limerick-2								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	33	41	26	25	0.13	30.14	4	20
February	32	39	25	23	0.07	30.00	5	21
March	39	47	31	26	0.08	29.95	7	20
April	50	63	39	37	0.12	30.13	5	20
May	61	72	51	50	0.10	30.08	3	18
June	71	81	62	62	0.25	29.93	3	20
July	77	85	69	68	0.15	30.05	3	18
August	71	79	62	63	0.17	30.04	2	18
September	64	75	52	54	0.03	30.05	2	19
October	56	66	46	47	0.09	30.08	3	19
November	41	50	32	29	0.08	30.19	5	22
December	34	42	26	28	0.15	30.12	4	20

Maine Yankee								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	23	32	14	13	0.04	30.04	3	20
February	26	34	18	16	0.10	29.93	4	21
March	34	42	26	23	0.06	29.88	4	19
April	43	53	33	30	0.08	30.12	4	19
May	53	64	43	44	0.18	30.06	3	18
June	64	74	54	55	0.21	29.90	3	19
July	71	81	62	64	0.11	30.02	2	18
August	66	78	55	58	0.08	29.98	2	18
September	59	69	49	52	0.29	29.99	2	19
October	49	61	38	42	0.05	30.06	2	20
November	36	45	27	26	0.13	30.08	4	21
December	23	31	14	18	0.16	30.07	2	19

McGuire-1								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	45	54	34	35	0.05	30.22	3	20
February	42	52	32	29	0.04	30.07	4	18
March	45	56	34	28	0.05	30.05	4	19
April	60	71	49	45	0.03	30.14	3	18
May	65	76	55	54	0.04	30.12	2	18
June	75	84	66	66	0.19	30.03	2	19
July	77	84	69	69	0.03	30.12	2	19
August	75	84	66	66	0.05	30.12	1	24
September	70	81	59	59	0.02	30.09	2	18
October	61	72	50	51	0.00	30.12	2	18
November	47	59	35	34	0.03	30.27	4	19
December	46	57	35	36	0.07	30.19	2	18

McGuire-2								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	45	54	34	35	0.05	30.22	3	20
February	42	52	32	29	0.04	30.07	4	18
March	45	56	34	28	0.05	30.05	4	19
April	60	71	49	45	0.03	30.14	3	18
May	65	76	55	54	0.04	30.12	2	18
June	75	84	66	66	0.19	30.03	2	19
July	77	84	69	69	0.03	30.12	2	19
August	75	84	66	66	0.05	30.12	1	24
September	70	81	59	59	0.02	30.09	2	18
October	61	72	50	51	0.00	30.12	2	18
November	47	59	35	34	0.03	30.27	4	19
December	46	57	35	36	0.07	30.19	2	18

Millstone-1								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	32	39	25	23	0.03	30.10	9	22
February	31	37	24	25	0.06	29.94	10	25
March	37	45	31	26	0.02	29.88	11	24
April	47	56	38	35	0.03	30.12	9	24
May	56	65	47	48	0.04	30.06	6	23
June	66	74	59	61	0.28	29.91	7	22
July	76	83	70	70	0.02	30.02	6	24
August	70	78	62	63	0.05	30.01	5	26
September	63	73	54	55	0.06	30.01	6	21
October	55	65	46	47	0.01	30.06	7	23
November	43	51	35	32	0.07	30.14	10	24
December	35	42	28	28	0.08	30.08	8	22

Millstone-2								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	32	39	25	23	0.03	30.10	9	22
February	31	37	24	25	0.06	29.94	10	25
March	37	45	31	26	0.02	29.88	11	24
April	47	56	38	35	0.03	30.12	9	24
May	56	65	47	48	0.04	30.06	6	23
June	66	74	59	61	0.28	29.91	7	22
July	76	83	70	70	0.02	30.02	6	24
August	70	78	62	63	0.05	30.01	5	26
September	63	73	54	55	0.06	30.01	6	21
October	55	65	46	47	0.01	30.06	7	23
November	43	51	35	32	0.07	30.14	10	24
December	35	42	28	28	0.08	30.08	8	22

Millstone-3								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	32	39	25	23	0.03	30.10	9	22
February	31	37	24	25	0.06	29.94	10	25
March	37	45	31	26	0.02	29.88	11	24
April	47	56	38	35	0.03	30.12	9	24
May	56	65	47	48	0.04	30.06	6	23
June	66	74	59	61	0.28	29.91	7	22
July	76	83	70	70	0.02	30.02	6	24
August	70	78	62	63	0.05	30.01	5	26
September	63	73	54	55	0.06	30.01	6	21
October	55	65	46	47	0.01	30.06	7	23
November	43	51	35	32	0.07	30.14	10	24
December	35	42	28	28	0.08	30.08	8	22

Monticello								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	15	23	7	10	0.01	30.05	7	19
February	16	24	7	12	0.02	30.00	6	19
March	24	32	15	18	0.03	30.10	6	19
April	38	45	31	28	0.05	29.97	8	20
May	55	65	46	42	0.13	29.97	7	19
June	66	75	58	55	0.15	29.92	5	19
July	72	81	62	58	0.07	30.01	5	18
August	71	81	60	58	0.03	30.02	4	18
September	64	75	54	53	0.05	29.97	5	19
October	46	54	39	38	0.09	29.95	7	19
November	30	39	22	22	0.03	30.09	7	20
December	8	17	0	4	0.01	30.09	6	19

Nine Mile Point-1								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	26	34	18	19	0.08	30.08	8	23
February	26	33	19	18	0.10	29.98	8	23
March	32	38	26	23	0.05	29.95	8	22
April	45	55	36	32	0.09	30.09	9	24
May	59	71	48	46	0.12	30.03	5	22
June	65	73	56	56	0.24	29.91	5	20
July	72	82	63	64	0.11	30.02	4	20
August	68	78	58	59	0.08	30.01	4	20
September	60	70	49	52	0.12	30.02	4	21
October	52	61	44	44	0.15	30.03	5	22
November	37	44	29	27	0.14	30.13	9	24
December	27	33	21	21	0.07	30.06	7	21

Nine Mile Point-2								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	26	34	18	19	0.08	30.08	8	23
February	26	33	19	18	0.10	29.98	8	23
March	32	38	26	23	0.05	29.95	8	22
April	45	55	36	32	0.09	30.09	9	24
May	59	71	48	46	0.12	30.03	5	22
June	65	73	56	56	0.24	29.91	5	20
July	72	82	63	64	0.11	30.02	4	20
August	68	78	58	59	0.08	30.01	4	20
September	60	70	49	52	0.12	30.02	4	21
October	52	61	44	44	0.15	30.03	5	22
November	37	44	29	27	0.14	30.13	9	24
December	27	33	21	21	0.07	30.06	7	21

North Anna-1								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	39	49	30	29	0.13	30.16	4	19
February	37	47	27	24	0.06	30.01	4	19
March	40	51	29	26	0.09	29.96	5	19
April	57	70	45	41	0.09	30.10	5	18
May	64	76	52	54	0.12	30.07	4	18
June	74	84	64	66	0.28	29.95	3	19
July	78	87	69	71	0.09	30.06	3	20
August	74	83	64	67	0.25	30.05	2	19
September	67	78	55	59	0.04	30.04	2	16
October	59	70	48	52	0.09	30.07	3	17
November	45	56	33	32	0.12	30.21	4	19
December	41	51	32	32	0.21	30.12	4	18

North Anna-2								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	39	49	30	29	0.13	30.16	4	19
February	37	47	27	24	0.06	30.01	4	19
March	40	51	29	26	0.09	29.96	5	19
April	57	70	45	41	0.09	30.10	5	18
May	64	76	52	54	0.12	30.07	4	18
June	74	84	64	66	0.28	29.95	3	19
July	78	87	69	71	0.09	30.06	3	20
August	74	83	64	67	0.25	30.05	2	19
September	67	78	55	59	0.04	30.04	2	16
October	59	70	48	52	0.09	30.07	3	17
November	45	56	33	32	0.12	30.21	4	19
December	41	51	32	32	0.21	30.12	4	18

Oconee-1								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	49	58	41	37	0.23	30.19	4	22
February	46	55	37	29	0.14	30.05	6	21
March	49	60	39	29	0.15	30.03	6	22
April	62	73	52	46	0.14	30.10	4	20
May	68	78	59	54	0.13	30.07	4	19
June	77	87	69	66	0.20	29.99	3	20
July	78	86	71	69	0.51	30.08	3	21
August	77	85	71	67	0.45	30.08	3	24
September	74	83	66	62	0.08	30.04	3	20
October	65	74	56	53	0.07	30.09	3	20
November	51	60	41	35	0.12	30.23	4	19
December	49	57	40	36	0.22	30.16	4	20

Oconee-2								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	49	58	41	37	0.23	30.19	4	22
February	46	55	37	29	0.14	30.05	6	21
March	49	60	39	29	0.15	30.03	6	22
April	62	73	52	46	0.14	30.10	4	20
May	68	78	59	54	0.13	30.07	4	19
June	77	87	69	66	0.20	29.99	3	20
July	78	86	71	69	0.51	30.08	3	21
August	77	85	71	67	0.45	30.08	3	24
September	74	83	66	62	0.08	30.04	3	20
October	65	74	56	53	0.07	30.09	3	20
November	51	60	41	35	0.12	30.23	4	19
December	49	57	40	36	0.22	30.16	4	20

Oconee-3								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	49	58	41	37	0.23	30.19	4	22
February	46	55	37	29	0.14	30.05	6	21
March	49	60	39	29	0.15	30.03	6	22
April	62	73	52	46	0.14	30.10	4	20
May	68	78	59	54	0.13	30.07	4	19
June	77	87	69	66	0.20	29.99	3	20
July	78	86	71	69	0.51	30.08	3	21
August	77	85	71	67	0.45	30.08	3	24
September	74	83	66	62	0.08	30.04	3	20
October	65	74	56	53	0.07	30.09	3	20
November	51	60	41	35	0.12	30.23	4	19
December	49	57	40	36	0.22	30.16	4	20

Palo Verde-1								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	54	65	42	25	0.04	30.09	5	21
February	57	68	46	28	0.01	30.00	5	22
March	70	83	56	29	0.03	29.92	5	19
April	76	88	62	26	0.00	29.79	7	22
May	84	96	72	30	0.00	29.79	8	22
June	95	108	81	33	0.00	29.70	7	21
July	96	106	86	60	0.07	29.77	8	22
August	95	105	84	55	0.02	29.80	7	23
September	89	100	78	49	0.03	29.73	7	21
October	75	87	62	31	0.00	29.87	6	21
November	67	77	56	38	0.08	29.96	6	20
December	57	68	45	30	0.01	30.05	5	20

Palo Verde-2								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	54	65	42	25	0.04	30.09	5	21
February	57	68	46	28	0.01	30.00	5	22
March	70	83	56	29	0.03	29.92	5	19
April	76	88	62	26	0.00	29.79	7	22
May	84	96	72	30	0.00	29.79	8	22
June	95	108	81	33	0.00	29.70	7	21
July	96	106	86	60	0.07	29.77	8	22
August	95	105	84	55	0.02	29.80	7	23
September	89	100	78	49	0.03	29.73	7	21
October	75	87	62	31	0.00	29.87	6	21
November	67	77	56	38	0.08	29.96	6	20
December	57	68	45	30	0.01	30.05	5	20

Palo Verde-3								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	54	65	42	25	0.04	30.09	5	21
February	57	68	46	28	0.01	30.00	5	22
March	70	83	56	29	0.03	29.92	5	19
April	76	88	62	26	0.00	29.79	7	22
May	84	96	72	30	0.00	29.79	8	22
June	95	108	81	33	0.00	29.70	7	21
July	96	106	86	60	0.07	29.77	8	22
August	95	105	84	55	0.02	29.80	7	23
September	89	100	78	49	0.03	29.73	7	21
October	75	87	62	31	0.00	29.87	6	21
November	67	77	56	38	0.08	29.96	6	20
December	57	68	45	30	0.01	30.05	5	20

Peach Bottom-1								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	36	41	30	26	0.00	30.19	5	29
February	37	42	32	27	0.00	29.98	6	26
March	41	48	34	28	0.00	29.94	8	28
April	55	65	46	43	0.00	30.10	7	26
May	65	74	58	57	0.00	30.10	6	23
June	73	81	66	64	0.00	29.91	4	-
July	78	85	71	70	0.00	30.03	4	-
August	73	80	68	66	0.00	30.01	4	-
September	66	75	57	56	0.00	30.07	4	-
October	60	67	52	52	0.00	30.07	5	28
November	43	50	36	32	0.00	30.24	5	26
December	38	44	32	29	0.00	30.15	4	-

Peach Bottom-2								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	36	41	30	26	0.00	30.19	5	29
February	37	42	32	27	0.00	29.98	6	26
March	41	48	34	28	0.00	29.94	8	28
April	55	65	46	43	0.00	30.10	7	26
May	65	74	58	57	0.00	30.10	6	23
June	73	81	66	64	0.00	29.91	4	-
July	78	85	71	70	0.00	30.03	4	-
August	73	80	68	66	0.00	30.01	4	-
September	66	75	57	56	0.00	30.07	4	-
October	60	67	52	52	0.00	30.07	5	28
November	43	50	36	32	0.00	30.24	5	26
December	38	44	32	29	0.00	30.15	4	-

Peach Bottom-3

	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	36	41	30	26	0.00	30.19	5	29
February	37	42	32	27	0.00	29.98	6	26
March	41	48	34	28	0.00	29.94	8	28
April	55	65	46	43	0.00	30.10	7	26
May	65	74	58	57	0.00	30.10	6	23
June	73	81	66	64	0.00	29.91	4	-
July	78	85	71	70	0.00	30.03	4	-
August	73	80	68	66	0.00	30.01	4	-
September	66	75	57	56	0.00	30.07	4	-
October	60	67	52	52	0.00	30.07	5	28
November	43	50	36	32	0.00	30.24	5	26
December	38	44	32	29	0.00	30.15	4	-

Perry-1

	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	33	37	27	24	0.00	30.10	13	25
February	29	35	24	22	0.00	29.98	12	25
March	35	39	30	26	0.00	29.99	12	25
April	50	59	41	36	0.00	30.05	12	24
May	64	73	55	48	0.00	30.04	10	21
June	69	76	62	59	0.00	29.95	8	20
July	74	81	67	66	0.00	30.06	8	25
August	71	78	63	61	0.00	30.07	8	23
September	65	73	56	56	0.00	30.06	9	22
October	56	63	49	48	0.00	30.04	10	23
November	40	45	34	29	0.00	30.17	13	25
December	33	37	28	25	0.00	30.06	12	24

Pilgrim-1

	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	31	39	22	21	0.06	30.07	8	23
February	31	36	25	22	0.12	29.93	8	23
March	37	44	30	26	0.11	29.87	9	23
April	47	57	37	34	0.07	30.12	8	22
May	58	69	47	48	0.14	30.06	6	21
June	68	77	59	58	0.34	29.92	7	21
July	76	84	68	68	0.09	30.02	6	20
August	69	79	59	59	0.07	30.01	5	19
September	62	72	52	53	0.06	30.01	5	20
October	53	64	42	44	0.04	30.07	5	22
November	41	50	32	29	0.14	30.12	8	24
December	33	41	25	26	0.11	30.07	8	23

Piqua

	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	29	36	21	25	0.07	30.12	10	21
February	29	35	23	25	0.02	29.98	10	21
March	33	39	27	28	0.04	30.01	9	20
April	50	61	40	40	0.15	30.03	8	21
May	63	73	54	52	0.10	30.02	7	21
June	69	78	60	60	0.13	29.92	6	18
July	71	79	62	65	0.05	30.06	4	18
August	69	80	58	62	0.04	30.07	3	19
September	65	77	52	54	0.05	30.05	4	17
October	53	63	43	46	0.09	30.05	5	19
November	38	45	31	31	0.06	30.19	9	20
December	30	37	32	26	0.12	30.09	9	20

Point Beach-1

	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	21	29	14	14	0.05	30.03	11	22
February	20	27	14	15	0.05	29.96	10	22
March	26	33	20	18	0.05	30.05	9	21
April	39	46	33	29	0.11	29.99	10	22
May	52	62	43	41	0.05	30.00	7	21
June	63	71	55	55	0.17	29.91	6	20
July	68	76	59	61	0.08	30.03	5	20
August	67	77	58	60	0.04	30.04	5	19
September	60	70	51	54	0.08	30.07	6	20
October	49	57	41	42	0.15	30.03	8	21
November	35	41	28	28	0.10	30.16	11	25
December	18	26	10	13	0.01	30.12	10	22

Point Beach-2

	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	21	29	14	14	0.05	30.03	11	22
February	20	27	14	15	0.05	29.96	10	22
March	26	33	20	18	0.05	30.05	9	21
April	39	46	33	29	0.11	29.99	10	22
May	52	62	43	41	0.05	30.00	7	21
June	63	71	55	55	0.17	29.91	6	20
July	68	76	59	61	0.08	30.03	5	20
August	67	77	58	60	0.04	30.04	5	19
September	60	70	51	54	0.08	30.07	6	20
October	49	57	41	42	0.15	30.03	8	21
November	35	41	28	28	0.10	30.16	11	25
December	18	26	10	13	0.01	30.12	10	22

Prairie Island-1

	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	17	26	9	11	0.03	30.05	6	19
February	19	27	11	14	0.03	29.99	6	18
March	25	34	17	17	0.06	30.08	6	19
April	40	48	33	30	0.18	29.95	7	19
May	57	67	47	45	0.17	29.96	6	19
June	67	76	58	57	0.14	29.90	5	19
July	72	83	61	60	0.04	29.99	5	18
August	71	83	59	60	0.04	30.01	3	17
September	65	77	53	54	0.07	29.97	6	18
October	48	57	38	39	0.08	29.94	6	19
November	31	41	22	23	0.02	30.10	7	20
December	12	21	4	7	0.02	30.09	6	19

Prairie Island-2

	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	17	26	9	11	0.03	30.05	6	19
February	19	27	11	14	0.03	29.99	6	18
March	25	34	17	17	0.06	30.08	6	19
April	40	48	33	30	0.18	29.95	7	19
May	57	67	47	45	0.17	29.96	6	19
June	67	76	58	57	0.14	29.90	5	19
July	72	83	61	60	0.04	29.99	5	18
August	71	83	59	60	0.04	30.01	3	17
September	65	77	53	54	0.07	29.97	6	18
October	48	57	38	39	0.08	29.94	6	19
November	31	41	22	23	0.02	30.10	7	20
December	12	21	4	7	0.02	30.09	6	19

Quad Cities-2

	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	23	32	13	16	0.06	30.13	11	24
February	25	32	17	18	0.04	30.01	13	24
March	29	36	22	21	0.06	30.09	10	24
April	47	57	36	34	0.21	30.02	12	24
May	61	72	51	48	0.13	29.98	11	22
June	70	78	61	56	0.14	29.95	9	21
July	71	81	60	51	0.06	30.06	6	19
August	71	81	60	61	0.02	30.07	6	18
September	65	78	52	53	0.06	30.04	8	19
October	50	61	39	40	0.08	30.02	9	20
November	34	44	24	26	0.06	30.18	10	22
December	18	27	9	14	0.00	30.11	9	23

R.E. Ginna								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	31	38	22	22	0.07	30.07	10	25
February	27	33	21	19	0.15	29.98	10	25
March	34	40	27	24	0.04	29.97	10	22
April	47	57	36	32	0.11	30.08	11	24
May	62	72	50	47	0.14	30.04	8	23
June	67	75	58	57	0.27	29.92	7	22
July	73	82	64	64	0.21	30.04	6	22
August	70	79	59	59	0.11	30.02	6	20
September	61	71	50	52	0.09	30.04	7	20
October	54	63	44	45	0.12	30.04	7	22
November	38	45	30	27	0.10	30.14	11	24
December	29	36	21	22	0.11	30.07	9	24

Rancho Seco								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	41	53	29	34	0.00	30.12	3	21
February	46	59	33	35	0.00	30.14	4	22
March	54	67	41	42	0.00	30.07	4	21
April	60	75	46	41	0.00	30.00	8	22
May	65	80	50	42	0.00	29.96	7	19
June	71	87	55	49	0.00	29.87	6	18
July	74	92	56	49	0.00	29.86	6	17
August	72	89	55	51	0.00	29.90	6	17
September	69	83	55	49	0.00	29.87	6	19
October	61	77	46	39	0.00	29.97	4	22
November	54	67	41	38	0.00	30.05	4	23
December	44	57	31	31	0.00	30.17	3	23

Salem-1								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	36	44	28	26	0.13	30.17	7	24
February	35	42	27	25	0.11	30.02	10	25
March	41	49	32	26	0.09	29.96	11	25
April	54	64	44	39	0.11	30.14	9	24
May	64	74	53	52	0.07	30.08	8	21
June	73	82	64	63	0.49	29.93	7	23
July	80	87	72	69	0.15	30.04	7	21
August	74	82	65	64	0.21	30.04	6	22
September	66	77	55	55	0.07	30.04	6	21
October	59	69	49	49	0.07	30.08	8	23
November	44	54	34	30	0.10	30.21	9	25
December	38	46	29	29	0.18	30.13	7	23

Salem-2								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	36	44	28	26	0.13	30.17	7	24
February	35	42	27	25	0.11	30.02	10	25
March	41	49	32	26	0.09	29.96	11	25
April	54	64	44	39	0.11	30.14	9	24
May	64	74	53	52	0.07	30.08	8	21
June	73	82	64	63	0.49	29.93	7	23
July	80	87	72	69	0.15	30.04	7	21
August	74	82	65	64	0.21	30.04	6	22
September	66	77	55	55	0.07	30.04	6	21
October	59	69	49	49	0.07	30.08	8	23
November	44	54	34	30	0.10	30.21	9	25
December	38	46	29	29	0.18	30.13	7	23

San Onofre-1								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	56	65	47	35	0.02	30.13	4	22
February	57	64	49	39	0.01	30.10	5	21
March	60	66	54	47	0.03	30.06	5	20
April	62	67	57	48	0.00	30.00	7	20
May	66	70	61	53	0.01	29.97	8	19
June	67	71	63	56	0.00	29.92	7	19
July	71	74	66	60	0.00	29.94	6	18
August	71	76	66	59	0.00	29.94	6	19
September	72	77	66	60	0.00	29.86	6	19
October	66	73	60	51	0.01	29.98	6	20
November	64	71	57	48	0.02	30.02	4	22
December	60	69	50	38	0.01	30.10	4	20

San Onofre-2								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	56	65	47	35	0.02	30.13	4	22
February	57	64	49	39	0.01	30.10	5	21
March	60	66	54	47	0.03	30.06	5	20
April	62	67	57	48	0.00	30.00	7	20
May	66	70	61	53	0.01	29.97	8	19
June	67	71	63	56	0.00	29.92	7	19
July	71	74	66	60	0.00	29.94	6	18
August	71	76	66	59	0.00	29.94	6	19
September	72	77	66	60	0.00	29.86	6	19
October	66	73	60	51	0.01	29.98	6	20
November	64	71	57	48	0.02	30.02	4	22
December	60	69	50	38	0.01	30.10	4	20

San Onofre-3								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	56	65	47	35	0.02	30.13	4	22
February	57	64	49	39	0.01	30.10	5	21
March	60	66	54	47	0.03	30.06	5	20
April	62	67	57	48	0.00	30.00	7	20
May	66	70	61	53	0.01	29.97	8	19
June	67	71	63	56	0.00	29.92	7	19
July	71	74	66	60	0.00	29.94	6	18
August	71	76	66	59	0.00	29.94	6	19
September	72	77	66	60	0.00	29.86	6	19
October	66	73	60	51	0.01	29.98	6	20
November	64	71	57	48	0.02	30.02	4	22
December	60	69	50	38	0.01	30.10	4	20

SeaBrook-1								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	27	35	19	16	0.03	30.05	8	24
February	28	35	21	17	0.11	29.94	9	26
March	35	43	28	24	0.08	29.88	9	23
April	46	56	37	31	0.07	30.11	9	23
May	56	66	46	47	0.15	30.04	6	22
June	67	77	58	58	0.22	29.90	7	24
July	74	82	65	66	0.11	30.01	5	22
August	69	79	59	58	0.06	29.98	6	20
September	61	72	51	53	0.21	29.99	6	22
October	52	62	42	43	0.01	30.06	5	22
November	39	47	30	25	0.08	30.09	9	23
December	28	34	21	21	0.07	30.07	7	22

Sequoyah-1								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	46	54	37	37	0.32	30.21	5	21
February	44	53	35	32	0.16	30.07	6	22
March	47	57	38	33	0.19	30.07	7	22
April	61	72	49	47	0.31	30.08	5	20
May	68	78	57	55	0.24	30.05	4	20
June	78	88	68	66	0.16	29.97	4	23
July	78	86	70	69	0.33	30.05	4	28
August	78	86	70	68	0.24	30.07	3	22
September	74	84	64	63	0.08	30.03	3	21
October	63	74	52	52	0.01	30.10	3	19
November	48	58	38	34	0.15	30.25	6	22
December	45	54	36	36	0.31	30.18	4	21

Sequoyah-2								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	46	54	37	37	0.32	30.21	5	21
February	44	53	35	32	0.16	30.07	6	22
March	47	57	38	33	0.19	30.07	7	22
April	61	72	49	47	0.31	30.08	5	20
May	68	78	57	55	0.24	30.05	4	20
June	78	88	68	66	0.16	29.97	4	23
July	78	86	70	69	0.33	30.05	4	28
August	78	86	70	68	0.24	30.07	3	22
September	74	84	64	63	0.08	30.03	3	21
October	63	74	52	52	0.01	30.10	3	19
November	48	58	38	34	0.15	30.25	6	22
December	45	54	36	36	0.31	30.18	4	21

Shearon Harris-1								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	44	55	32	36	0.07	30.20	3	19
February	41	53	30	30	0.11	30.04	4	18
March	44	57	32	29	0.06	30.01	4	19
April	59	72	47	48	0.10	30.12	4	18
May	65	77	54	56	0.08	30.10	4	18
June	75	84	65	67	0.32	29.98	3	19
July	78	86	69	71	0.15	30.08	2	17
August	75	84	65	67	0.08	30.06	2	19
September	67	80	54	58	0.18	30.02	2	16
October	56	66	46	49	0.01	30.09	3	18
November	47	60	35	37	0.07	30.23	3	18
December	47	57	36	39	0.07	30.15	3	18

Shippingport								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	32	37	27	23	0.00	30.12	8	20
February	29	34	23	20	0.00	29.97	8	20
March	35	40	29	23	0.00	29.97	7	19
April	51	61	42	33	0.00	30.06	8	21
May	63	73	53	45	0.00	30.05	7	20
June	69	77	61	56	0.00	29.96	5	19
July	72	80	65	62	0.00	30.08	4	20
August	70	79	62	60	0.00	30.07	4	17
September	64	72	54	54	0.00	30.07	4	17
October	55	63	47	46	0.00	30.06	5	19
November	39	45	32	29	0.00	30.16	8	20
December	34	38	29	27	0.00	30.05	7	19

Shoreham								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	33	41	26	24	0.08	30.12	8	22
February	32	38	26	23	0.17	29.97	9	24
March	38	45	31	26	0.09	29.91	9	23
April	49	58	40	36	0.05	30.14	8	23
May	57	67	49	49	0.08	30.07	6	20
June	69	77	61	61	0.28	29.92	7	20
July	77	84	71	69	0.07	30.03	6	19
August	71	79	63	62	0.08	30.03	5	20
September	63	73	54	55	0.10	30.03	5	21
October	56	66	47	47	0.01	30.08	5	21
November	43	51	35	32	0.09	30.16	9	23
December	36	43	29	29	0.18	30.10	7	22

South Texas-1								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	56	67	46	50	0.05	30.15	8	20
February	60	71	50	51	0.04	30.01	8	21
March	62	74	49	51	0.01	30.08	8	21
April	68	78	57	61	0.09	29.96	9	20
May	75	84	67	68	0.03	29.98	8	20
June	83	94	73	74	0.06	29.94	5	18
July	84	93	74	74	0.07	29.98	5	19
August	85	93	76	75	0.05	29.98	4	18
September	82	90	74	75	0.14	29.91	5	18
October	73	83	63	66	0.19	30.01	5	18
November	61	70	52	54	0.09	30.16	7	20
December	54	63	44	47	0.01	30.16	7	20

South-Texas-2								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	56	67	46	50	0.05	30.15	8	20
February	60	71	50	51	0.04	30.01	8	21
March	62	74	49	51	0.01	30.08	8	21
April	68	78	57	61	0.09	29.96	9	20
May	75	84	67	68	0.03	29.98	8	20
June	83	94	73	74	0.06	29.94	5	18
July	84	93	74	74	0.07	29.98	5	19
August	85	93	76	75	0.05	29.98	4	18
September	82	90	74	75	0.14	29.91	5	18
October	73	83	63	66	0.19	30.01	5	18
November	61	70	52	54	0.09	30.16	7	20
December	54	63	44	47	0.01	30.16	7	20

St. Lucie-1								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	70	77	63	62	0.02	30.17	6	19
February	68	76	60	57	0.01	30.07	6	20
March	63	72	54	49	0.00	30.08	6	20
April	76	82	69	66	0.01	30.05	8	20
May	76	83	69	66	0.08	30.04	7	19
June	81	87	75	73	0.03	30.03	5	19
July	81	87	75	73	0.03	30.08	5	21
August	82	88	77	73	0.01	30.04	5	19
September	80	87	74	70	0.05	29.97	5	19
October	78	84	71	65	0.00	30.01	5	18
November	74	80	68	61	0.03	30.08	10	22
December	72	78	66	62	0.02	30.14	6	19

St. Lucie-2								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	70	77	63	62	0.02	30.17	6	19
February	68	76	60	57	0.01	30.07	6	20
March	63	72	54	49	0.00	30.08	6	20
April	76	82	69	66	0.01	30.05	8	20
May	76	83	69	66	0.08	30.04	7	19
June	81	87	75	73	0.03	30.03	5	19
July	81	87	75	73	0.03	30.08	5	21
August	82	88	77	73	0.01	30.04	5	19
September	80	87	74	70	0.05	29.97	5	19
October	78	84	71	65	0.00	30.01	5	18
November	74	80	68	61	0.03	30.08	10	22
December	72	78	66	62	0.02	30.14	6	19

Surry-1								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	42	51	33	34	0.18	30.20	5	19
February	42	50	33	30	0.14	30.04	6	19
March	45	54	35	31	0.12	29.99	7	20
April	61	72	50	48	0.13	30.13	6	19
May	68	78	58	57	0.18	30.09	5	18
June	77	85	68	68	0.33	29.97	5	18
July	81	90	73	72	0.24	30.07	4	17
August	77	85	68	69	0.22	30.06	3	18
September	72	82	61	62	0.03	30.05	3	16
October	64	73	54	56	0.11	30.07	4	18
November	50	61	39	38	0.08	30.23	5	19
December	46	55	36	37	0.19	30.16	5	19

Surry-2								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	42	51	33	34	0.18	30.20	5	19
February	42	50	33	30	0.14	30.04	6	19
March	45	54	35	31	0.12	29.99	7	20
April	61	72	50	48	0.13	30.13	6	19
May	68	78	58	57	0.18	30.09	5	18
June	77	85	68	68	0.33	29.97	5	18
July	81	90	73	72	0.24	30.07	4	17
August	77	85	68	69	0.22	30.06	3	18
September	72	82	61	62	0.03	30.05	3	16
October	64	73	54	56	0.11	30.07	4	18
November	50	61	39	38	0.08	30.23	5	19
December	46	55	36	37	0.19	30.16	5	19

Susquehann-1								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	30	37	22	21	0.09	30.10	6	22
February	29	35	23	19	0.06	29.98	8	22
March	35	42	27	23	0.09	29.94	9	22
April	50	60	39	32	0.07	30.10	8	23
May	60	72	48	44	0.10	30.06	6	21
June	69	79	58	57	0.20	29.92	6	20
July	76	85	65	64	0.06	30.04	5	19
August	70	81	59	58	0.05	30.03	5	19
September	62	74	50	50	0.07	30.04	5	20
October	55	66	44	44	0.06	30.06	4	20
November	39	47	30	26	0.12	30.16	8	22
December	32	38	24	24	0.13	30.08	7	21

Susquehanna-2								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	30	37	22	21	0.09	30.10	6	22
February	29	35	23	19	0.06	29.98	8	22
March	35	42	27	23	0.09	29.94	9	22
April	50	60	39	32	0.07	30.10	8	23
May	60	72	48	44	0.10	30.06	6	21
June	69	79	58	57	0.20	29.92	6	20
July	76	85	65	64	0.06	30.04	5	19
August	70	81	59	58	0.05	30.03	5	19
September	62	74	50	50	0.07	30.04	5	20
October	55	66	44	44	0.06	30.06	4	20
November	39	47	30	26	0.12	30.16	8	22
December	32	38	24	24	0.13	30.08	7	21

Three Mile Island-1

	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	33	40	26	23	0.12	30.15	7	25
February	32	39	25	23	0.09	30.01	8	27
March	39	46	31	25	0.11	29.97	10	24
April	53	63	42	37	0.09	30.11	8	24
May	63	73	52	50	0.09	30.07	6	23
June	72	81	63	61	0.15	29.92	6	22
July	78	86	70	67	0.17	30.03	5	23
August	73	81	64	63	0.11	30.03	4	19
September	66	77	55	54	0.04	30.04	4	20
October	58	67	48	47	0.39	30.07	5	20
November	41	50	32	28	0.10	30.20	8	24
December	34	42	27	26	0.15	30.12	5	22

Three Mile Island-2

	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	33	40	26	23	0.12	30.15	7	25
February	32	39	25	23	0.09	30.01	8	27
March	39	46	31	25	0.11	29.97	10	24
April	53	63	42	37	0.09	30.11	8	24
May	63	73	52	50	0.09	30.07	6	23
June	72	81	63	61	0.15	29.92	6	22
July	78	86	70	67	0.17	30.03	5	23
August	73	81	64	63	0.11	30.03	4	19
September	66	77	55	54	0.04	30.04	4	20
October	58	67	48	47	0.39	30.07	5	20
November	41	50	32	28	0.10	30.20	8	24
December	34	42	27	26	0.15	30.12	5	22

Trojan

	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	37	41	33	32	0.11	30.25	5	18
February	43	49	37	37	0.07	30.22	5	18
March	47	56	39	39	0.09	30.14	3	18
April	50	59	42	40	0.12	30.17	4	19
May	57	67	48	45	0.18	30.08	4	18
June	63	73	53	51	0.04	30.03	3	17
July	35	77	54	51	0.00	30.07	4	18
August	67	76	57	55	0.01	30.03	3	18
September	61	69	54	53	0.27	29.93	4	19
October	51	60	42	43	0.05	30.17	3	18
November	44	51	37	38	0.12	30.17	4	19
December	36	40	32	31	0.09	30.33	4	18

Turkey Point-3								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	71	78	65	64	0.01	30.15	7	21
February	70	78	62	61	0.03	30.07	7	21
March	66	75	57	55	0.07	30.08	8	22
April	76	82	71	68	0.20	30.04	9	21
May	77	84	69	69	0.50	30.03	8	22
June	81	87	76	74	0.22	30.02	7	22
July	87	81	75	72	0.33	30.07	7	22
August	82	88	77	75	0.06	30.03	7	21
September	81	87	76	75	0.21	29.96	6	24
October	79	85	72	71	0.04	30.00	7	20
November	76	81	70	69	0.12	30.04	10	24
December	74	80	67	68	0.08	30.11	8	20

Turkey Point-4								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	71	78	65	64	0.01	30.15	7	21
February	70	78	62	61	0.03	30.07	7	21
March	66	75	57	55	0.07	30.08	8	22
April	76	82	71	68	0.20	30.04	9	21
May	77	84	69	69	0.50	30.03	8	22
June	81	87	76	74	0.22	30.02	7	22
July	87	81	75	72	0.33	30.07	7	22
August	82	88	77	75	0.06	30.03	7	21
September	81	87	76	75	0.21	29.96	6	24
October	79	85	72	71	0.04	30.00	7	20
November	76	81	70	69	0.12	30.04	10	24
December	74	80	67	68	0.08	30.11	8	20

Virgil C.Summer-1								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	53	64	41	40	0.05	30.19	5	21
February	48	59	36	34	0.22	30.05	6	22
March	51	63	39	32	0.12	30.03	7	22
April	65	77	53	51	0.16	30.10	6	22
May	71	81	59	56	0.14	30.06	6	21
June	79	88	70	69	0.25	29.97	6	22
July	81	88	73	73	0.40	30.06	5	23
August	80	88	71	70	0.30	30.05	4	19
September	76	87	65	63	0.07	30.01	5	18
October	67	78	55	55	0.08	30.07	4	19
November	53	65	40	40	0.08	30.22	5	26
December	52	63	41	42	0.20	30.16	4	20

Virgil C. Summer-2								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	53	64	41	40	0.05	30.19	5	21
February	48	59	36	34	0.22	30.05	6	22
March	51	63	39	32	0.12	30.03	7	22
April	65	77	53	51	0.16	30.10	6	22
May	71	81	59	56	0.14	30.06	6	21
June	79	88	70	69	0.25	29.97	6	22
July	81	88	73	73	0.40	30.06	5	23
August	80	88	71	70	0.30	30.05	4	19
September	76	87	65	63	0.07	30.01	5	18
October	67	78	55	55	0.08	30.07	4	19
November	53	65	40	40	0.08	30.22	5	26
December	52	63	41	42	0.20	30.16	4	20

Virgil C. Summer-3								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	53	64	41	40	0.05	30.19	5	21
February	48	59	36	34	0.22	30.05	6	22
March	51	63	39	32	0.12	30.03	7	22
April	65	77	53	51	0.16	30.10	6	22
May	71	81	59	56	0.14	30.06	6	21
June	79	88	70	69	0.25	29.97	6	22
July	81	88	73	73	0.40	30.06	5	23
August	80	88	71	70	0.30	30.05	4	19
September	76	87	65	63	0.07	30.01	5	18
October	67	78	55	55	0.08	30.07	4	19
November	53	65	40	40	0.08	30.22	5	26
December	52	63	41	42	0.20	30.16	4	20

Vogtle-1								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	53	65	39	40	0.02	30.20	5	21
February	48	60	36	35	0.38	30.06	6	23
March	51	64	38	33	0.11	30.05	7	22
April	63	76	49	51	0.15	30.09	5	21
May	69	81	56	57	0.08	30.06	6	21
June	78	88	67	69	0.40	29.98	5	22
July	80	88	71	72	0.31	30.06	4	23
August	78	88	69	70	0.20	30.05	4	21
September	75	87	62	64	0.04	30.02	4	20
October	65	78	52	55	0.01	30.08	3	20
November	53	66	39	40	0.06	30.22	5	22
December	51	63	38	42	0.24	30.17	4	21

Vogtle-2								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	53	65	39	40	0.02	30.20	5	21
February	48	60	36	35	0.38	30.06	6	23
March	51	64	38	33	0.11	30.05	7	22
April	63	76	49	51	0.15	30.09	5	21
May	69	81	56	57	0.08	30.06	6	21
June	78	88	67	69	0.40	29.98	5	22
July	80	88	71	72	0.31	30.06	4	23
August	78	88	69	70	0.20	30.05	4	21
September	75	87	62	64	0.04	30.02	4	20
October	65	78	52	55	0.01	30.08	3	20
November	53	66	39	40	0.06	30.22	5	22
December	51	63	38	42	0.24	30.17	4	21

Vogtle-3								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	53	65	39	40	0.02	30.20	5	21
February	48	60	36	35	0.38	30.06	6	23
March	51	64	38	33	0.11	30.05	7	22
April	63	76	49	51	0.15	30.09	5	21
May	69	81	56	57	0.08	30.06	6	21
June	78	88	67	69	0.40	29.98	5	22
July	80	88	71	72	0.31	30.06	4	23
August	78	88	69	70	0.20	30.05	4	21
September	75	87	62	64	0.04	30.02	4	20
October	65	78	52	55	0.01	30.08	3	20
November	53	66	39	40	0.06	30.22	5	22
December	51	63	38	42	0.24	30.17	4	21

Vogtle-4								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	53	65	39	40	0.02	30.20	5	21
February	48	60	36	35	0.38	30.06	6	23
March	51	64	38	33	0.11	30.05	7	22
April	63	76	49	51	0.15	30.09	5	21
May	69	81	56	57	0.08	30.06	6	21
June	78	88	67	69	0.40	29.98	5	22
July	80	88	71	72	0.31	30.06	4	23
August	78	88	69	70	0.20	30.05	4	21
September	75	87	62	64	0.04	30.02	4	20
October	65	78	52	55	0.01	30.08	3	20
November	53	66	39	40	0.06	30.22	5	22
December	51	63	38	42	0.24	30.17	4	21

Waterfor-3								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	56	64	49	49	0.17	30.18	9	22
February	58	65	50	49	0.21	30.05	9	23
March	59	69	49	46	0.03	30.11	9	22
April	68	76	60	59	0.24	30.02	9	26
May	73	81	65	63	0.24	30.04	7	22
June	83	90	75	72	0.14	29.97	5	23
July	82	89	75	72	0.12	30.02	6	21
August	83	90	75	74	0.17	30.02	5	20
September	82	89	74	73	0.21	29.96	5	21
October	73	80	65	64	0.06	30.05	6	21
November	60	68	52	50	0.05	30.18	10	24
December	55	63	48	48	0.07	30.17	9	24

Watts bar-1								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	40	47	32	32	0.24	30.19	6	20
February	38	47	30	28	0.09	30.04	6	21
March	40	49	31	30	0.20	30.04	7	21
April	56	66	45	42	0.26	30.08	6	21
May	63	73	53	52	0.25	30.06	5	19
June	71	80	63	63	0.13	30.00	4	19
July	73	80	64	65	0.30	30.09	3	18
August	73	81	65	65	0.11	30.10	3	18
September	69	79	59	60	0.11	30.06	3	17
October	58	68	48	49	0.03	30.10	3	19
November	43	53	33	32	0.14	30.24	5	20
December	40	48	31	32	0.22	30.16	5	20

Watts bar-2								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	40	47	32	32	0.24	30.19	6	20
February	38	47	30	28	0.09	30.04	6	21
March	40	49	31	30	0.20	30.04	7	21
April	56	66	45	42	0.26	30.08	6	21
May	63	73	53	52	0.25	30.06	5	19
June	71	80	63	63	0.13	30.00	4	19
July	73	80	64	65	0.30	30.09	3	18
August	73	81	65	65	0.11	30.10	3	18
September	69	79	59	60	0.11	30.06	3	17
October	58	68	48	49	0.03	30.10	3	19
November	43	53	33	32	0.14	30.24	5	20
December	40	48	31	32	0.22	30.16	5	20

Wolf Creek								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	34	46	22	23	0.02	30.18	10	26
February	34	44	23	24	0.09	30.04	11	25
March	40	50	29	29	0.07	30.08	11	25
April	50	60	40	38	0.13	29.97	12	25
May	64	73	53	53	0.16	29.94	11	24
June	75	85	64	62	0.05	29.91	11	24
July	77	89	65	62	0.20	30.00	8	22
August	76	86	66	67	0.16	30.02	8	21
September	72	84	59	59	0.10	29.97	9	22
October	56	67	44	45	0.18	30.02	10	23
November	42	53	30	29	0.03	30.20	12	28
December	29	41	17	20	0.02	30.16	10	25

Yankee Rowe								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	25	34	16	15	0.05	30.08	7	22
February	25	32	18	14	0.04	29.97	8	23
March	32	40	24	19	0.06	29.91	7	21
April	44	56	33	27	0.08	30.11	7	23
May	57	70	45	42	0.24	30.05	4	21
June	65	76	55	55	0.24	29.92	3	20
July	73	83	63	63	0.06	30.03	2	18
August	66	77	55	56	0.19	30.02	2	20
September	59	71	47	49	0.22	30.03	2	20
October	50	61	40	40	0.07	30.07	4	20
November	36	45	27	23	0.11	30.13	7	23
December	28	36	20	21	0.07	30.07	6	22

Zion-1								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	26	35	17	18	0.10	30.10	9	22
February	24	32	16	19	0.10	29.99	8	21
March	30	37	23	22	0.06	30.07	8	20
April	45	53	36	34	0.32	29.99	9	23
May	57	67	46	47	0.11	29.97	8	21
June	65	74	55	56	0.16	29.91	6	21
July	70	79	61	62	0.08	30.01	5	20
August	70	80	59	61	0.05	30.03	5	20
September	63	73	53	55	0.09	30.01	6	20
October	50	59	41	44	0.12	29.99	6	20
November	36	44	28	28	0.07	30.16	9	22
December	21	29	12	17	0.03	30.10	8	21

Zion-2								
	Ave. Mean Temp. ('F)	Ave. Max Temp. ('F)	Ave. Min Temp. ('F)	Ave. Dew Point ('F)	Ave. Precipitation (inch)	Ave. Sea Level Pressure (inch)	Ave. Wind Speed (mph)	Ave. Gust Speed (mph)
January	26	35	17	18	0.10	30.10	9	22
February	24	32	16	19	0.10	29.99	8	21
March	30	37	23	22	0.06	30.07	8	20
April	45	53	36	34	0.32	29.99	9	23
May	57	67	46	47	0.11	29.97	8	21
June	65	74	55	56	0.16	29.91	6	21
July	70	79	61	62	0.08	30.01	5	20
August	70	80	59	61	0.05	30.03	5	20
September	63	73	53	55	0.09	30.01	6	20
October	50	59	41	44	0.12	29.99	6	20
November	36	44	28	28	0.07	30.16	9	22
December	21	29	12	17	0.03	30.10	8	21

Table 3. Averaged weather data for regions near nuclear power plants.

* Note that the weather data collected will work for short distance Gaussian Plume modeling; however, more complex meteorological data suited for HYSPLIT will need to be collected.

Appendix E

Matlab plotting source code.

```
%This program was written for the RAVEN project on Sep 30th 2014.

%The purpose of this program is to plot the RAVEN data
% into a histogram using frequency of dose.

ddata=csvread('1000N.csv',0,1); %Reads in the RAVEN Data

%nrcb and nrca are created as empty vectors
% They will be used to store the doses above and below
% the fictitious 0.175 rem limit.

%Sets the fictitious regulatory limit
reglim=0.175;

nrcb=[];
nrca=[];

%The following for loop tests the RAVEN data and then writes it to
% nrca and nrcb. The test checks to see if the dose is above or below
% our fictitious regulation limit. It then writes it to the
% nrc vectors, nrca for above and nrcb for below.

for i=1:length(ddata) %Loop for length of RAVEN data

    if ddata(i)>=reglim %Test the data if it is above or equal to 0.175 rem

        nrca(end+1,1)=ddata(i); %Write the above data to nrca

    else %If no above or equal, else below 0.175

        nrcb(end+1,1)=ddata(i); %Write the below data to nrcb

    end

end

%The histogram is two separate plots, the plot of above the limit and
% a plot of the below limit. The reason for this is to make the above
% limit plot appear in red and the below data in grey.

numbin=20; %Defines the number of histogram bins

%Create the ranges for below the limit
dbrange=linspace(0,reglim-0.000001,numbin);
darange=linspace(reglim,0.35,numbin);% Bin Ranges for above.

% The following code is used to change frequency into a percentage.

cntsb=hist(nrcb,dbrange); %Creates a vector for # of counts in each range
cntsa=hist(nrca,darange); %Creates a vector for # of counts in each range

tcnt=sum(cntsb)+sum(cntsa); %Sums all counts in all ranges

cntsb=cntsb./tcnt; %Divides the counts in nrcb by the total
cntsa=cntsa./tcnt; %Divides the counts in nrca by the total

% Plots the new % counts with the ranges for nrcb
bar(dbrange,cntsb)
```

```
% Freezes the figure so that multiple plots appear on the same figure
hold on

% Plots the new % counts with the ranges for nrca
bar(darange,cntsa)

% h is a variable which provides an object handle to the plots. h is a
% vector with each element referencing each plot nrca, nrcb.
h=findobj(gca,'Type','patch');

%set changes the visual properties of the handle h for each element.
% h(2) is nrcb and h(1) is nrca. This is where the color is changed.
set(h(2),'FaceColor',[0 0.5 0.5],'EdgeColor','w')
set(h(1),'FaceColor',[1 0 0],'EdgeColor','w')

%yaxismax is the ymax value for the distribution plot
yaxismax=ylim;

% The following command draws a vertical line at the regulatory limit
% to the top of the graph.
line([reglim reglim],[0 yaxismax(1,2)],'Color', [0 0 0],'LineWidth',2)

%Adds text to the graph indicating the line for dose limit
text(reglim,yaxismax(1,2)/2 ...
    ,'\leftarrow Regulatory Dose Limit'...
    ,'FontName', 'Arial','FontSize',18)

% the following sets the title and axis labels for the plot.
title('Dose Distribution for Silent Cone Peak', 'FontName', 'Arial' ...
    , 'FontSize', 18)
xlabel('Dose Ranges in Rem', 'FontName', 'Arial' ...
    , 'FontSize', 18)
ylabel('Frequency in %', 'FontName', 'Arial' ...
    , 'FontSize', 18)

%Sets the xmin and xmax for the graph.
xlim([-0.005 0.35])

%Sets the font for the axes
set(gca,'FontSize', 14, 'FontName', 'Arial')
%clears all variables.
clear variables
```

Appendix F

controlmake.py source code.

```
SOURCE_TERM='ravenout.csv'
starttime='14 07 29 16 50'
plumeloc='43.5844 -112.9686 0'
runtime='3'
stoptime='14 05 14 19 50'
weatherfileloc='/home/ed/projects/Hysplit/hysplit_r577/Release/'
weatherfile='ARWDATA.BIN'
OUTPUT='cdump'

source= open(SOURCE_TERM, 'r')
control=open('CONTROL', 'w')

data=source.readline()

#start time
control.write(starttime)
control.write('\n')

#number of plumes
control.write('1')
control.write('\n')

#plume location
control.write(plumeloc)
control.write('\n')

#total runtime in hrs
control.write(runtime)
control.write('\n')

# vertical motion option (default 0)
control.write('0')
control.write('\n')

#max height
control.write('5000.0')
control.write('\n')

#number of input data grids
control.write('2')
control.write('\n')

#location of weather file(s)
control.write(weatherfileloc)
control.write('\n')
control.write(weatherfile)
```

```
control.write('\n')
control.write(weatherfileloc)
control.write('\n')
control.write(weatherfile + '20')
control.write('\n')

# number of pollutants
control.write('1')
control.write('\n')

#pollutant ID
control.write('CS37')
control.write('\n')

#mass units released per hour (from raven file)
control.write(data)
control.write('\n')

#hours of emission
control.write('1.0')
control.write('\n')

#release start time
control.write(starttime)
control.write('\n')

#number of concentration grids
control.write('1')
control.write('\n')

#center of grids default center of source
control.write('43.5844 -112.9686')
control.write('\n')

#interval between nodes of sampling grid
control.write('0.01 0.01')
control.write('\n')

#grid span in degrees
control.write('5.0 5.0')
control.write('\n')

#output directory and filename
control.write('./')
control.write('\n')
control.write(OUTPUT)
```

```
control.write('\n')

#number of vertical levels, 1 for ground 1 for sky
control.write('1')
control.write('\n')
#height of each level
control.write('0')
control.write('\n')

#sampling start time
control.write(starttime)
control.write('\n')
#sampling stop time
control.write(stoptime)
control.write('\n')

#sampling interval: type, hour, minute
control.write('0 0 180')
control.write('\n')

#number of pollutants depositing
control.write('1')
control.write('\n')

#particle diameter (um) density (g/cc), shape
control.write('1.0 1.873 1.0')
control.write('\n')

#deposition velocity (m/s)
control.write('4.3e-03 0.0 0.0 0.0 0.0')
control.write('\n')

#henrys cst,in-cloud (L/L), below cloud(l/s) Suggested:0.0 4.0E+04 5.0E-06
control.write('0.0 3.2e+05 5.0e-05')
control.write('\n')

#halflife days
control.write('11019.4')
control.write('\n')

#resuspension
control.write('1.0e-06')

source.close()
control.close()
```